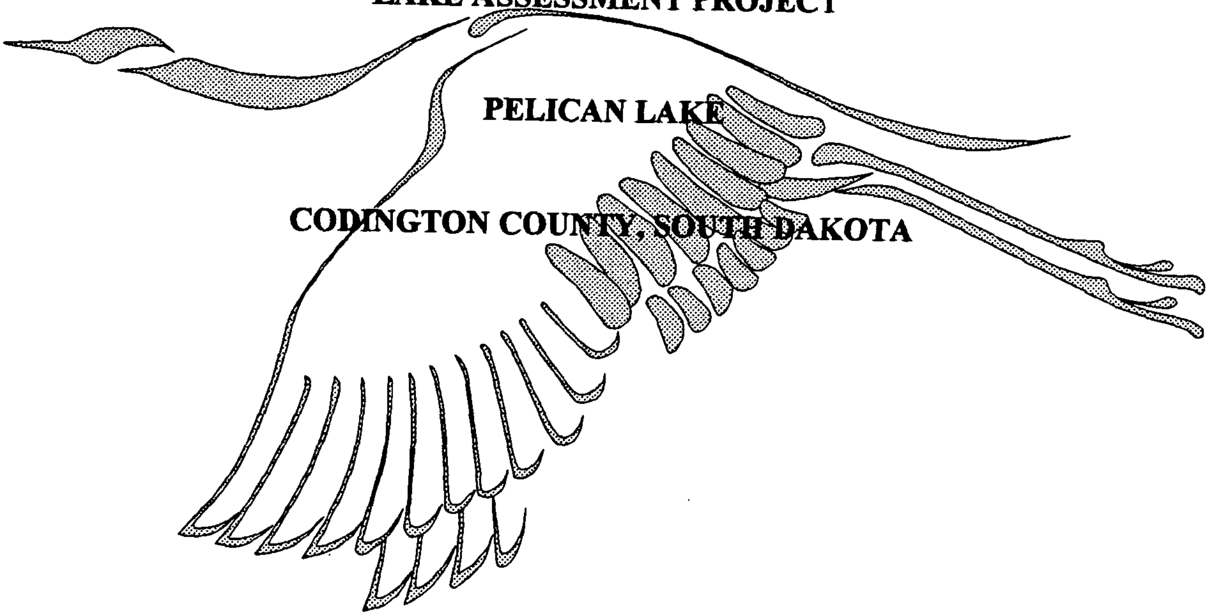
LAKE ASSESSMENT PROJECT

PELICAN LAKE

CODINGTON COUNTY, SOUTH DAKOTA



South Dakota Clean Lakes Program
Division of Water Resources Management
South Dakota Department of
Environment and Natural Resources
Nettie H. Myers, Secretary

April, 1995

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Pelican Lake Water Project District

April, 1995

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LAKE IDENTIFICATION AND LOCATION

Lake Name: Pelican Lake

State: South Dakota

County: Codington County, South Dakota

Nearest Municipality: Watertown, South Dakota

Latitude: 44 deg. 52 min. 12 sec. N

Longitude: 97 deg. 10 min. 24 sec. N

EPA Region: VIII

Major Tributary: Big Sioux River

Receiving Body of Water: Big Sioux River

WATER QUALITY STANDARDS

The surface water quality standards for Pelican Lake are shown below:

1. Beneficial Use Classifications

   a. Warmwater Semipermanent Fish Life Propagation Waters: surface waters of the state which support aquatic life and are suitable for the propagation or maintenance, or both, of warmwater fish but which may suffer occasional fish kills because of critical natural conditions.

   b. Immersion Recreation Waters: surface waters of the state which are suitable for uses where the human body may come in direct contact with the water, to the point of complete submersion and where water may be accidentally ingested or where certain sensitive organs such as the eyes, ears, and nose may be exposed to water.

   c. Limited-Contact Recreation Waters: surface waters of the state which are suitable for boating, fishing, and other water-related recreation other than immersion recreation where a person's water contact would be limited to the extent that infections of eyes, ears, respiratory or digestive systems, or urogenital areas would normally be avoided.

   d. Wildlife Propagation and Stock Watering Waters: surface waters of the state which are satisfactory as habitat for aquatic and semiaquatic wild animals and fowl, provide natural food chain maintenance, and are of suitable quality for watering domestic and wild animals.

2. Applicable Criteria

   Water quality criteria for the maintenance of these beneficial use classifications are shown in Table 1.

Table 1. Pelican Lake Water Quality Standards

Parameter	Standard
Total Dissolved Solids	<2500 mg/L
Nitrates	<50 mg/L (as N)
pH	>6.5 & <9.0 units
Fecal Coliform Organisms	<200 per 100 mL
Total Chlorine Residual	<0.02 mg/L
Un-ionized Ammonia Nitrogen	<0.04 mg/L (as N)
Dissolved Oxygen	>5.0 mg/L
Undisassociated Hydrogen Sulfide	<0.002 mg/L
Suspended Solids	<90 mg/L
Temperature	<90 deg. F
Total Alkalinity	<750 mg/L
Conductivity	<4000 micro-ohms/cm

The surface water quality standards for the Big Sioux River, the major tributary to Pelican Lake are as follows:

1. Beneficial Use Classifications

    a. Domestic Water Supply Waters: surface waters of the state which are suitable for human consumption, culinary or food processing purposes, and other household purposes after suitable conventional treatment.

    b. Warmwater Semipermanent Fish Life Propagation Waters: surface waters of the state which support aquatic life and are suitable for the propagation or maintenance, or both, of warmwater fish but which may suffer occasional fish kills because of critical natural conditions.

    c. Limited-Contact Recreation Waters: surface waters of the state which are suitable for boating, fishing, and other water-related recreation other than immersion recreation where a person's water contact would be limited to the extent that infections of eyes, ears, respiratory or digestive systems, or urogenital areas would normally be avoided.

    d. Wildlife Propagation and Stock Watering Waters: surface waters of the state which are satisfactory as habitat for aquatic and semiaquatic wild animals and fowl, provide natural food chain maintenance, and are of suitable quality for watering domestic and wild animals.

    e. Irrigation Waters: surface waters of the state which are suitable for irrigating farm lands, ranch lands, gardens, and recreational areas.

2. Applicable Criteria

    Water quality criteria for the maintenance of these beneficial use classifications are shown in Table 2.

Table 2. Big Sioux River Water Quality Standards

Parameter	Standard
Total Dissolved Solids	<1000 mg/L
Nitrates	<10 mg/L (as N)
pH	>6.5 & <9.0 units
Fecal Coliform Organisms	<1000 per 100 mL
Barium	<1 mg/L
Chloride	<250 mg/L
Fluoride	<4.0 mg/L
Sulfate	<500 mg/L
Total Chlorine Residual	<0.02 mg/L
Un-ionized Ammonia Nitrogen	<0.04 mg/L (as N)
Dissolved Oxygen	>5.0 mg/L
Undisassociated Hydrogen Sulfide	<0.002 mg/L

Table 2. (continued).

Parameter	Standard
Suspended Solids	<90 mg/L
Temperature	<90 deg. F
Total Alkalinity	<750 mg/L
Conductivity	<2500 micro-ohms/cm
Sodium Adsorption Ratio	<10

Three unnamed, intermittent streams which flow into Pelican Lake were monitored during the Lake Assessment Project. The surface water quality standards for these streams are shown below:

1. Beneficial Use Classifications

   a. Wildlife Propagation and Stock Watering Waters: surface waters of the state which are satisfactory as habitat for aquatic and semiaquatic wild animals and fowl and are of suitable quality for watering domestic and wild animals.

   b. Irrigation Waters: surface waters of the state which are suitable for irrigating farm lands, ranch lands, gardens, and recreational areas.

2. Applicable Criteria

   Water quality criteria for the maintenance of these beneficial use classifications are shown in Table 3.

Table 3. Intermittent Stream Water Quality Standards

Parameter	Standard
Total Alkalinity	<750 mg/L
Total Dissolved Solids	<2500 mg/L
Conductivity	<2500 micro-ohms/cm
Nitrates	<50 mg/L (as N)
pH	>6.0 & < 9.5 units
Sodium Adsorption Ratio	<10

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

In August, 1993, the South Dakota Department of Environment and Natural Resources (SD DENR) initiated a joint state/local Lake Assessment Project (LAP) at Pelican Lake near Watertown, South Dakota. The LAP was undertaken in cooperation with the Pelican Lake Water Project District.

Tributary stream monitoring equipment was installed during the fall of 1993, and watershed sampling began in March, 1994. Water quality monitoring of the lake began in September, 1993. Water samples were collected by a local representative of the DENR, with assistance from members of the Pelican Lake Water Project District. The tributaries in the watershed were monitored primarily during spring snowmelt runoff and after rainstorm events. Samples were also collected periodically during base flow conditions. The in-lake water samples were collected monthly from September, 1993, to August, 1994. Both tributary and in-lake samples were sent to the State Health Laboratory in Pierre, South Dakota, for analysis.

In-lake sampling results indicate that Pelican Lake is hypereutrophic. Hypereutrophic is a term which means the lake has an overabundance of nutrients and sediment. Nutrients such as nitrogen and phosphorus are used by algae and macrophytes for growth and reproduction. The high levels of nutrients and sediment are primarily originating from extensive agricultural practices in the watershed. An analysis of the immediate watershed indicated that 87% of the area is in agricultural use. The nutrients and sediments are carried into the lake mainly through the inlet channel from the Big Sioux River. Although there is a strong hydraulic connection between Pelican Lake and the Big Sioux Aquifer, nutrient concentrations in the ground water are very low compared to the concentrations found during the surface water monitoring program in the watershed Therefore, ground water recharge of Pelican Lake is not considered a significant source of nutrients.

The water quality monitoring of the tributaries showed high concentrations of phosphorus, nitrogen, and solids. Loadings of these materials into the lake were found to be the greatest during periods of high water flow. Each high flow event resulted in poor water quality in the tributaries, and major loadings of sediment and nutrients into Pelican Lake. High fecal coliform bacteria results were also found during periods of high flow. Feedlots were the most probable sources of the high fecal coliform bacteria results. There are at least 23 livestock feeding operations in the immediate watershed. Other possible sources of fecal coliform bacteria in the watershed may be overflows or discharges from septic wastewater systems into ditches, waterways, and field tiles. A survey was conducted of septic wastewater systems in the immediate area around the lake. The results indicated that 27% of the existing wastewater septic systems around Pelican Lake have drainfields that would not meet present construction standards.

Because the inlet from the Big Sioux River into Pelican Lake also serves as the lake outlet, it was difficult at times to determine whether water was flowing into or out of the lake. This was especially true because of the width and depth of the inlet channel. Despite these complications, quite accurate measurements were made of flows into and out of the lake during the lake assessment project. By combining flow measurements with water quality concentrations, loadings of sediment and nutrients could be calculated. The results of these calculations indicate that Pelican Lake is acting as a sediment and nutrient retention basin for the Big Sioux River watershed, as well as the immediate watershed.

The in-lake water quality monitoring program showed high levels of nutrients and solids. In addition, a seismic sediment survey of the lake bottom indicated an accumulation of over 36 million cubic yards of silt. A survey of the Pelican Lake shoreline revealed that in spite of past efforts, there are still numerous areas of severe and moderate erosion. These areas of erosion are directly contributing to the overall siltation of Pelican Lake.

Based on the results of the lake assessment project, the alternatives listed below are suggested to help control the loadings of sediment, nutrients, and other contaminants into Pelican Lake:

Immediate Watershed Activities

1) Big Sioux River diversion control structure
2) Lake shoreline stabilization/management
3) Construction of animal waste management systems
4) Septic system alternative implementation
5) Information/Education program to promote Best Management Practices
6) Selective in-lake sediment removal
7) No-Till / Crop Residue Management /Integrated Crop Management
8) Construction/repair of grassed waterways in cropland fields
9) Promotion of the Conservation Reserve Program (CRP)
10) Streambank stabilization / riparian area management
11) Construction of small ponds and dams on watershed tributaries
12) Wetland restoration on prior converted wetlands or farmed wetlands

Big Sioux River Watershed Activities

1) Construction of small ponds and dams on watershed tributaries
2) Construction/repair of grassed waterways in cropland fields
3) Planting of vegetative filter strips/grass seedings along watershed streams
4) Construction of animal waste management systems
5) Streambank stabilization / riparian area management
6) Wetland restoration on prior converted wetlands or farmed wetlands
7) Promotion of the Conservation Reserve Program (CRP)

The immediate watershed and Big Sioux River watershed activities listed above are the alternatives which the South Dakota Department of Environment and Natural Resources recommends as the best solutions to the water quality problems identified during the assessment of Pelican Lake.

INTRODUCTION

General Description of Lake

Pelican Lake is a 2,796-acre lake located in Codington County in the glacial lake area of northeastern South Dakota. The lake lies partially within the City limits of Watertown, South Dakota. The Big Sioux River is the major tributary to the lake. The Pelican Lake immediate watershed area consists of approximately 13,065 acres. The diversion of the Big Sioux River into the lake in the 1930's added 212,707 acres of the Big Sioux River drainage basin to the Pelican Lake watershed.

Past and Present Lake Conditions

Like almost all lakes of the Prairie Coteau region, Pelican Lake has experienced water quality problems due in part to its shallow depth. The shallow depth of the lake results in high turbidity caused by re-suspension of bottom sediment from boat motors, wind, and bottom feeding fish. Algae blooms and loadings of sediment from the tributaries add to the turbidity problem. The high levels of turbidity give the water a cloudy, or murky, appearance. Because of the high turbidity there is, for the most part, an absence of macrophytes, or aquatic plants. Emergent vegetation presently covers only a small portion of the shoreline, and submergent vegetation is sparse to non-existent.

In spite of high turbidity levels, frequent blooms of nuisance blue-green algae occur in Pelican Lake. The blue-green algal species form floating mats typical of nutrient-rich lakes. The mats of algae accumulate along the shoreline and decompose. The resulting odors from decomposition are often quite offensive.

Comparison to Other Lakes in Area (TSI)

A well-documented effect of human impact upon aquatic ecosystems is eutrophication, a multifaceted term generally associated with increased productivity, structural simplification of biotic components, and a reduction in the ability of the metabolism of aquatic organisms to adapt to imposed changes (reduced stability). In this condition of eutrophication, excessive inputs, such as nutrients and sediment, commonly seem to exceed the capability of the ecosystem to be balanced (Wetzel, 1983). TSI, or Trophic State Index, is an indicator which can be used to measure relative levels of eutrophication for bodies of water. A trophic state index is calculated using several equations and actual measurements of total phosphorus, Secchi depth, and chlorophyll a. A TSI value can be calculated for each of these parameters. In addition, a mean TSI for a lake can be calculated by averaging the TSI results for all three of the parameters.

The Carlson Trophic State Index (Carlson, 1977) uses TSI values of 65 and greater to indicate hypereutrophic (very nutrient rich) bodies of water, values of 50 to 65 to indicate eutrophic bodies of water, and values of 35 to 50 to indicate mesotrophic (relatively nutrient poor) bodies of water. The South Dakota Department of Environment and Natural Resources has done statewide assessments of major lakes since 1989. Water quality results from these assessments have provided the opportunity to calculate TSI values for phosphorus, Secchi depth, and chlorophyll a, as well as mean TSI values, for the major lakes in the state (South Dakota Lakes Assessment Final Report, SD DENR, 1993). The table below provides a comparison of mean TSI values for Pelican Lake and other lakes within a 50-mile (80-kilometer) radius of Pelican Lake. The lakes are listed in order from highest mean TSI values (hypereutrophic) to lowest mean TSI values (mesotrophic).

Table 4. Comparison of Mean TSI Values for Lakes Within a 50-Mile Radius of Pelican Lake

Lake	Nearest Municipality	Mean TSI	Trophic State
Preston, Lake	Lake Preston, SD	90.48	Hypereutrophic
School Lake	Goodwin, SD	87.00	Hypereutrophic
Whitewood Lake	Lake Preston, SD	83.47	Hypereutrophic
Kampeska, Lake	Watertown, SD	82.34	Hypereutrophic
East Oakwood Lake	Bruce, SD	79.40	Hypereutrophic
Thompson, Lake	Lake Preston, SD	77.69	Hypereutrophic
Campbell, Lake	Brookings, SD	77.59	Hypereutrophic
Hendricks, Lake	Hendricks, MN	76.42	Hypereutrophic
Albert, Lake	Lake Norden, SD	75.48	Hypereutrophic
Alice, Lake	Altamont, SD	72.97	Hypereutrophic
Fish Lake	Astoria, SD	72.81	Hypereutrophic
Clear Lake	Clear Lake, SD	71.33	Hypereutrophic
Bullhead Lake	Goodwin, SD	69.72	Hypereutrophic
Poinsett, Lake	Estelline, SD	68.81	Hypereutrophic
Norden, Lake	Lake Norden, SD	68.23	Hypereutrophic
Pelican Lake	**Watertown, SD**	**67.97**	**Hypereutrophic**
Punished Woman's Lake	South Shore, SD	67.58	Hypereutrophic
Big Stone Lake	Ortonville, MN	67.24	Hypereutrophic
Cochrane, Lake	Gary, SD	49.30	Mesotrophic
Pickerel Lake	Grenville, SD	42.61	Mesotrophic
Enemy Swim Lake	Grenville, SD	39.74	Mesotrophic

From this comparison, it can be seen that Pelican Lake, like most of the other lakes within a 50-mile radius, is in a hypereutrophic condition. However, it should be noted that with a mean TSI value of 67.97, Pelican Lake is close to being classified as eutrophic (TSI less than 65). With a moderate change in water quality, Pelican Lake could be improved from a hypereutrophic to a eutrophic lake. As can be seen from the table above, the majority of lakes within the immediate area of Pelican Lake have worse water quality. With only a minor level of improvement, Pelican Lake could provide enhanced recreational opportunities that most of the other lakes in the area cannot provide.

Objective of Investigation

The purpose of the Pelican Lake Assessment Project was to assess the water quality of the lake and its tributary streams. The study was also intended to identify sources of nutrients and sediment that are causing the lake's degradation, and to propose feasible restoration alternatives to improve water quality in the lake and it's watershed area.

STUDY AREA DESCRIPTION

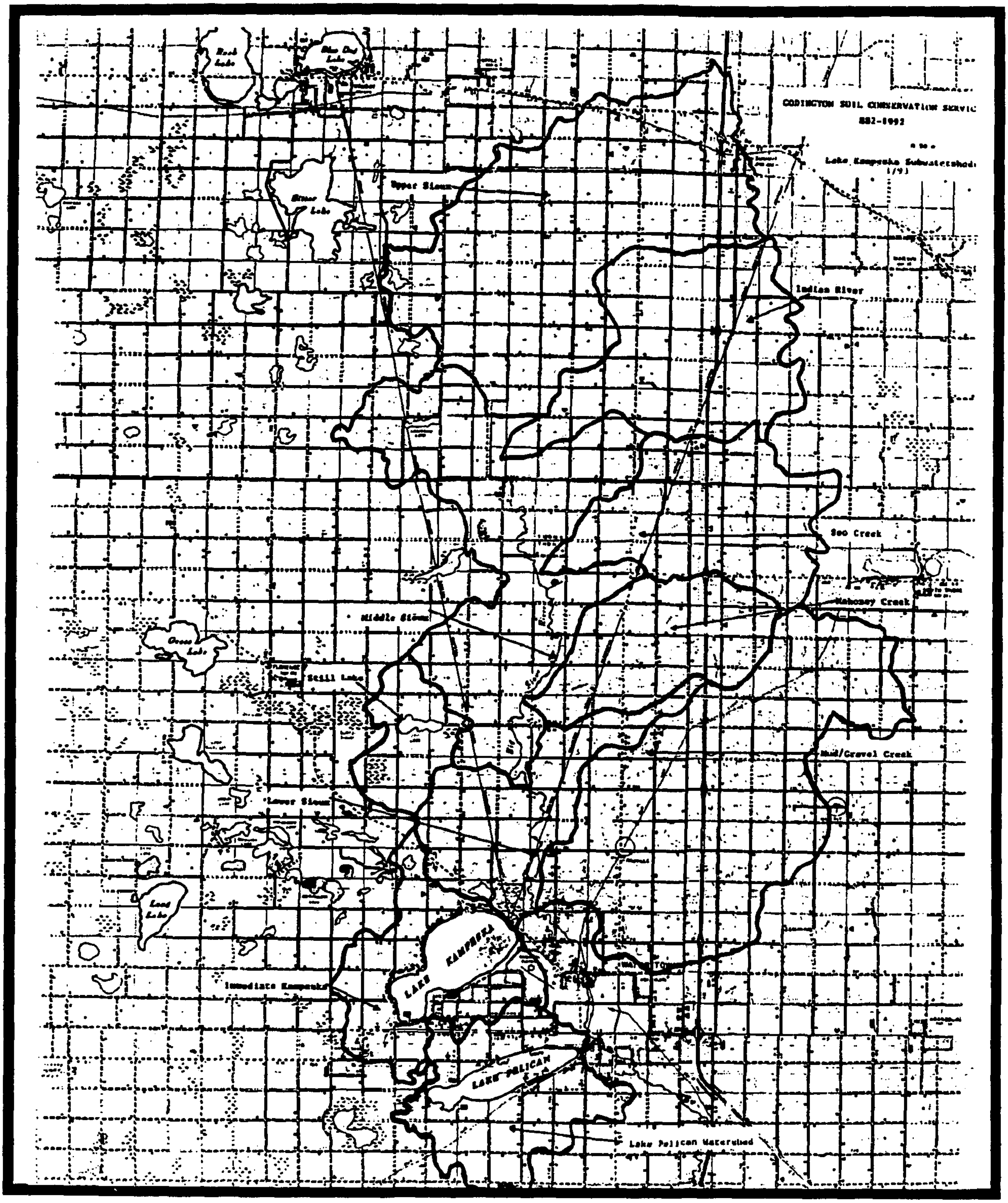


Figure 1. Pelican Lake / Lake Kampeska Watershed

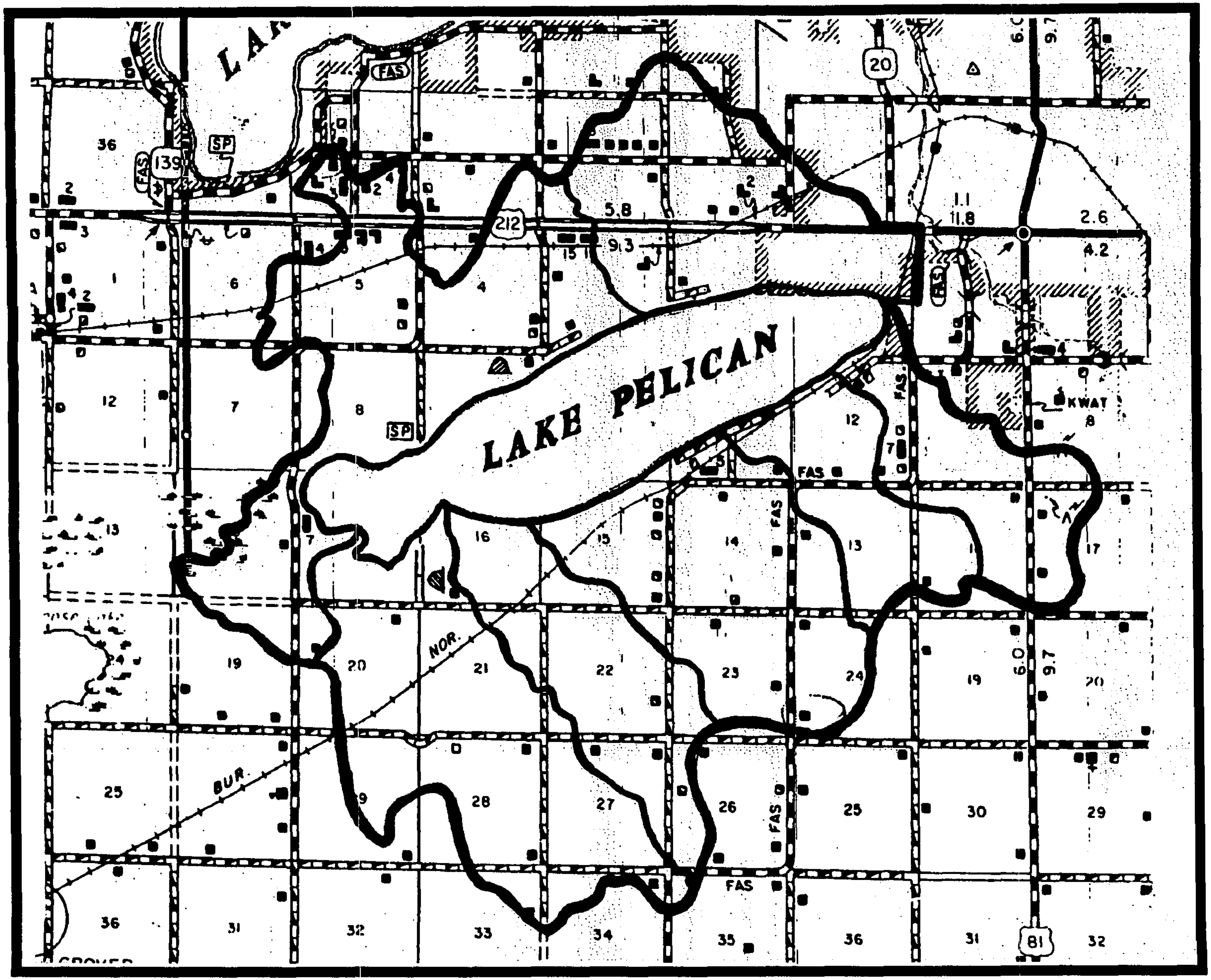


Figure 2. Pelican Lake Watershed

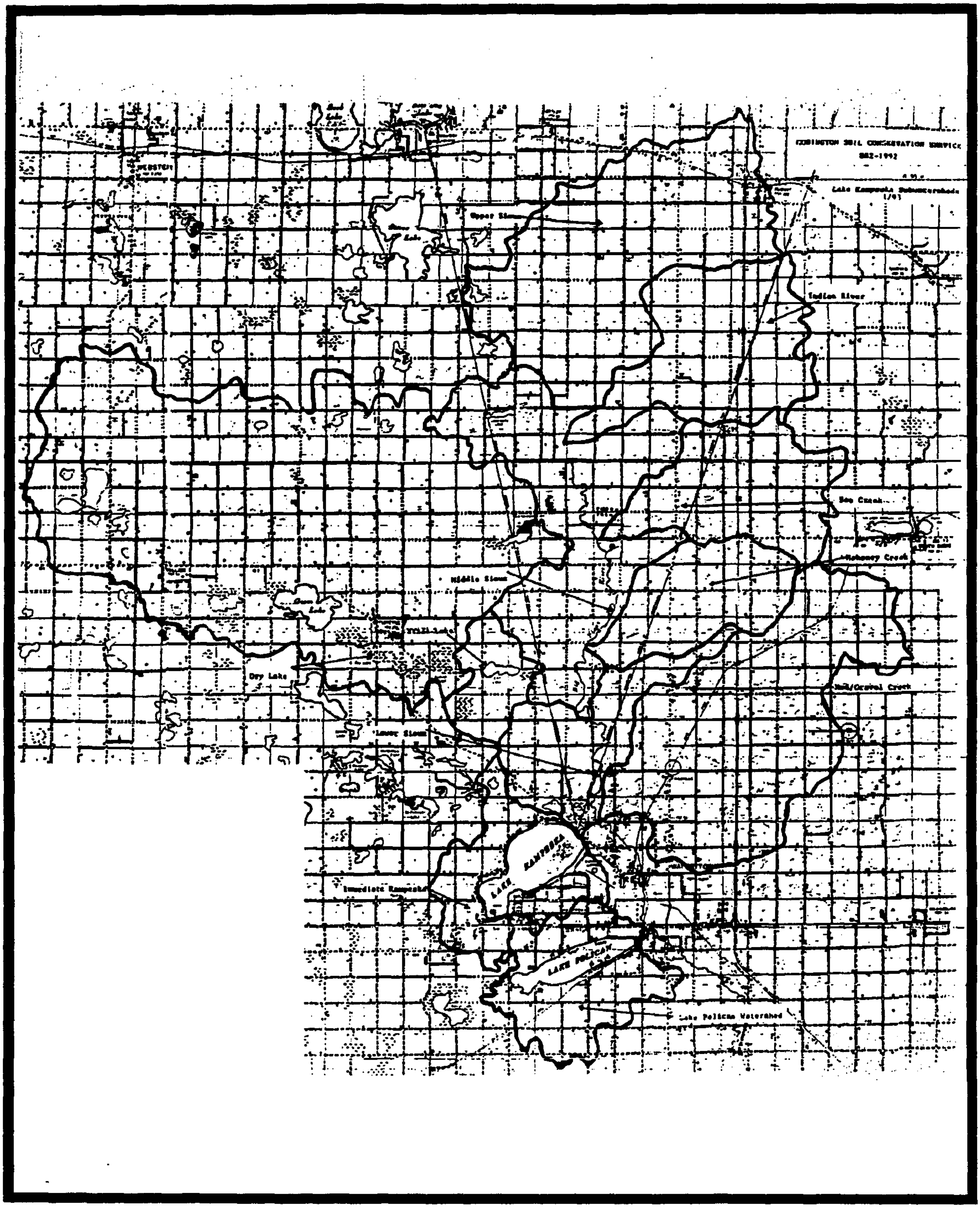


Figure 3. Pelican Lake, Lake Kampeska, Grass / Dry Lake Watershed

GEOLOGICAL AND SOILS DESCRIPTION OF DRAINAGE BASIN

Geology

Pelican Lake is a natural lake of glacial origin (Rothrock, 1933). Its existence is due to the action of glacial ice which covered northeastern South Dakota in the geologic past. Surficial deposits in the Pelican Lake study area can be divided into two main groups--(1) glacial deposits and (2) stream deposits (Barari, 1971).

Glacial deposits: During the Pleistocene Epoch of geologic time, ice moved into the Pelican Lake area and deposited glacial drift. Drift can be divided into till and outwash deposits. Till consists of a heterogeneous mixture of boulders, pebbles, and sand in a matrix of clay and silt directly deposited by the ice. Outwash material, on the other hand, is a sorted deposit consisting of mostly sand and gravel with minor amounts of clay deposited by meltwater streams originating from the ice.

Stream deposits: The Big Sioux River and some of its tributaries have deposited alluvium in their channels. Alluvium in the study area consists of sand, gravel, and clay.

No bedrock is exposed in the Pelican Lake study area. Data obtained from well logs in the area indicate that Cretaceous sedimentary rocks underlie the glacial drift. These deposits in descending order are the Pierre Shale, Niobrara Marl, Carlile Shale, Greenhorn Limestone, Graneros Shale, and the Dakota Formation. Beneath the Dakota Formation are granitic rocks of Precambrian age.

Topography

The topography of the Pelican Lake area ranges from nearly flat, well-drained, and gently undulating to rugged, poorly drained knob and kettle topography. Maximum relief in the study area is 150 feet with land elevations ranging from 1860 MSL northwest of the study area to 1710 MSL southeast of the study area.

The main stream in the area is the Big Sioux River which controls both surface and shallow ground water movement. Three unnamed streams in the immediate Pelican Lake watershed flow to Pelican Lake. The Big Sioux River and the three unnamed streams were monitored during the Lake Assessment Project.

Soils

Glacial drift is the parent material of the soils in the watershed. The drift is approximately 500 feet thick over bedrock. Many of the watershed soils were formed in loess that overlies the drift while some others were formed in alluvium. The Natural Resources Conservation Service has assigned the following general soils classifications for the Upper Big Sioux River and Pelican Lake watershed areas (Soil Survey of Codington County, South Dakota, 1966; Soil Survey of Day County, South Dakota, 1966; Soil Survey of Grant County, South Dakota, 1966; Soil Survey of Roberts County, South Dakota, 1966).

LAKE SHORELINE DEVELOPMENT

In analyzing the economic characteristics of the potential user population for Pelican Lake, it is useful to look at assessed tax valuations for property around the lake. This information is valuable, since the lake property owners are the primary user population. As of September 20, 1994, the assessed valuations for properties immediately adjoining Pelican Lake were as follows:

Buildings	
Residential	$3,954,280
Commercial	$32,240
Land	
Residential	$1,229,187
Commercial	$ 83,010
Total Assessed Property Value	$5,298,717

Source: Codington County Director of Equalization

It should be noted that the total assessed property value indicated in the previous table does not represent true market value, which would be significantly higher. The high value of property around Pelican Lake can be attributed in part to the sustained growth of the City of Watertown. Economic development has continued at a rapid pace, spurred in part by relocation of businesses and industries to Watertown. The associated population growth has created a high demand for homes and property. Nearly all the land around Lake Kampeska at Watertown has been developed, thus creating a greater demand for property and homes around Pelican Lake.

METHODS AND MATERIALS

IN-LAKE WATER QUALITY SAMPLING

Methods

Two in-lake monitoring sites were established for the lake assessment project. These were Site PL-6 (East) and Site PL-7 (West) (Figure 4). The sites were monitored by grab samples from the surface. Dissolved oxygen and temperature were measured on-site with a Yellow Springs Instruments oxygen meter (YSI model 51B). A Beckman pH meter (model GZ) was used for on-site analyses of pH levels. Secchi depth and water depth readings were measured with a standard 8-inch Secchi disk. During winter months samples were collected through holes drilled in the ice. No samples were collected during periods of unsafe ice. After ice-out, members of the Pelican Lake Water Project District provided boats for sample collection during open water months.

In-Lake Sampling Schedule

Each in-lake site was sampled once a month from September, 1993, to June, 1994, except for November and December, 1993, when there were hazardous ice conditions. Sampling was discontinued in June, 1994, to allow for lab results to be compiled. However, a decision was made to collect one more set of in-lake samples in August because of a major storm event on August 8, 1994.

Laboratory parameters which were analyzed to characterize the in-lake water quality were as follows:

Fecal Coliform Bacteria	Ammonia
Total Alkalinity	Nitrate + Nitrite Nitrogen
Total Solids	Total Dissolved Solids
Total Suspended Solids	Total Kjeldahl Nitrogen
Total Phosphorus	Total Dissolved Phosphorus
Chlorophyll *a*	

The in-lake samples for the above parameters were collected in separate bottles with appropriate preservatives. The bottles were packed in ice for shipment to the State Health Laboratory in Pierre, South Dakota.

Field parameters which were routinely measured by sample collection personnel on-site included the following:

Water Temperature	Dissolved Oxygen
Air Temperature	Field pH
Water Depth	Secchi Depth

Visual and climatological observations by sample collection personnel included, but were not limited to, the following:

Precipitation	Dead Fish
Wind	Surface Film on Water
Odor	Turbidity
Septic Conditions	Water Color

The in-lake sites were monitored for concentrations of the chemical parameters referenced previously. A summary of the concentrations for each site are included in Table 6.

An historic analysis was also performed for each parameter. A 1985 Lake Kampeska/Pelican Lake Water Quality Study Area Report (SD DWNR, May, 1985), and the 1993 South Dakota Lakes Assessment Final Report (SD DENR, March, 1994), were used for this historic analysis. A two-year monthly mean was calculated for the 1983 and 1984 data published in the 1985 report. Another mean was calculated using the 1983 and 1984 data from the 1985 report together with the 1989, 1991, and 1992 data from the 1993 report. These two mean values were plotted against current data to show trends in the chemical nature of Pelican Lake over the last ten years.

TRIBUTARY WATER QUALITY SAMPLING

Methods

Five tributary monitoring sites were placed in the Pelican Lake watershed to comprehensively monitor flows into the lake (Figure 4). Three sites were established on intermittent streams in the immediate watershed to monitor flows from known subwatershed areas. The names and locations of these sites were PL-1 (State Park), PL-2 (Air Haven), and PL-3 (Foley Road). These sites were selected to determine loadings from defined subwatershed areas, allowing an analysis and interpretation of each area's contribution to the in-lake degradation of Pelican Lake. An additional monitoring site was established on the Big Sioux River diversion, which flows into and out of Pelican Lake. This site was used to monitor both the inflow to, and the outflow from, Pelican Lake. When water was monitored flowing into Pelican lake the site was referred to as PL-4 (Big Sioux River inlet). When water was monitored flowing out of Pelican Lake the site was referred to as PL-5 (Big Sioux River outlet). All of the monitoring sites were established as fixed stage recording sites with Stevens Type F stage recorders. Water flows were routinely measured with a Marsh McBirney model 201D portable water current meter. The velocity readings were correlated with stage data to calculate stage discharge curves using U.S. Department of the Interior - Geological Survey forms (# 9-279). Daily average stages and discharges were also recorded on U. S. Geological Survey forms (# 9-192b). Field parameters recorded at the monitoring sites included visual observations, as well as temperature, dissolved oxygen (D.O.), and pH readings.

Tributary Sampling Schedule

The following schedule was observed for sampling at the intermittent stream sites (PL-1, PL-2, and PL-3). Samples were taken twice during the first week of snowmelt runoff. Samples were then taken at an average of once per week for the next eight weeks. During this eight-week period samples were taken to coincide with rain storm events. Additional samples were taken on August 8, 1994, after a major storm event. Samples were taken only during periods of flow. This resulted in a total of 21 samples for the three intermittent stream sites.

Sites PL-4 and PL-5 (Big Sioux River inlet and outlet) were sampled twice during the first week of snowmelt runoff. Samples were then taken once a week for the next five weeks, or whenever the flow direction changed in the Big Sioux River diversion channel. Additional samples were taken after storm events. A total of 12 samples were collected at Sites PL-4 and PL-5.

The laboratory parameters that were analyzed to characterize the lake inflow and outflow, and to develop a nutrient and sediment budget, were as follows:

Fecal Coliform Bacteria	Ammonia
Total Alkalinity	Nitrate + Nitrite Nitrogen
Total Solids	Total Dissolved Solids
Total Suspended Solids	Total Kjeldahl Nitrogen (TKN)
Total Phosphorus	Total Dissolved Phosphorus

The tributary samples for the above parameters were collected in separate bottles with appropriate preservatives. The bottles were packed in ice for shipment to the State Health Laboratory in Pierre, South Dakota.

Field parameters that were measured and recorded by sample collection personnel included the following:

Water Temperature	Dissolved Oxygen
Air Temperature	Field pH

Visual and climatological observations recorded by sample collection personnel included, but were not limited to the following:

Precipitation	Dead Fish
Wind	Surface Film on Water
Odor	Turbidity
Septic Conditions	Water Color

The tributary sites were monitored for the concentrations of chemical parameters as cited previously above. A summary table of the concentrations for each site are included in Table 16. Loadings of the chemical parameters at each site were also calculated and are included in Appendix A Tributary Loading Tables.

QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance/quality control (QA/QC) monitoring was conducted in accordance with methods set forth in "Standard Operating Procedures For Field Samplers" (SD DENR, Clean Lakes Program, 1992). Two types of samples were collected for QA/QC purposes: 1) field duplicates (replicates), and 2) blanks (distilled water). These samples were submitted, along with routine samples, to the South Dakota Department of Health Laboratory for analysis.

Water for the blank samples was obtained from commercial distilled water sources. The results for the blank samples (Table 5.) basically represent the detection limits of the laboratory equipment. Smaller detection limits could be obtained for some parameters such as nitrate-nitrogen, but this would result in an increase of analysis time and costs of the tests.

The overall accuracy for field duplicate samples was 90%. This is a high rate of accuracy, and demonstrates good quality assurance procedures for field sampling and laboratory procedures. These results do not indicate any need for changes in sampling or analysis techniques.

During the sampling period, no QA/QC samples exceeded recommended holding times for any parameters. These results, again, do not indicate any need for changes in either sample shipping or laboratory handling procedures.

TABLE 5. QA/QC RESULTS (BLANKS AND DUPLICATES)

DATE	SITE	DEPTH	FIELD pH	FECAL COLIFORM PER/100ML	TALKA L MG/L	TSOL MG/L	TSSOL MG/L	AMMON MG/L	NO3+2 MG/L	TKN-N MG/L	TPO4 MG/L	TDPO4 MG/L
3-17-94	PL-4B	SURF	5.97	<10	0.4	6.0	3.0	<0.02	<0.1	0.14	<0.005	<0.005
4-28-94	PL-6B	SURF	6.11	<10	3.0	9.0	<1	<0.02	<0.1	<0.10	0.007	0.007
3-17-94	PL-4	SURF	7.60	10	106	258	14	0.16	0.9	2.00	0.286	0.226
3-17-94	PL-4R	SURF	7.39	20	107	254	18	0.17	1.1	2.15	0.293	0.230
4-28-94	PL-6	SURF	7.83	<10	183	427	16	<0.02	<0.10	1.00	0.080	0.043
4-28-94	PL-6R	SURF	7.80	<10	183	430	18	<0.02	<0.10	0.91	0.083	0.033

RESULTS AND DISCUSSION

IN-LAKE MONITORING RESULTS

NITROGEN / PHOSPHORUS RATIO

An evaluation of the water quality results from the current lake assessment project indicated that phosphorus was the limiting nutrient for all but two in-lake sample dates (Figure 5). This trend establishes that Pelican Lake had high levels of available nitrogen during the study period from 1993 to 1994. The greatest limitation occurred during the sampling period from September 30, 1993, to March 15, 1994. After April 28, 1994, the limiting effect of phosphorus was not as pronounced. The results of the April 28, 1994, sample at Site PL-7 (West) and the June 20, 1994, sample at Site PL-6 (East) were the only indication of nitrogen limitation during the study period.

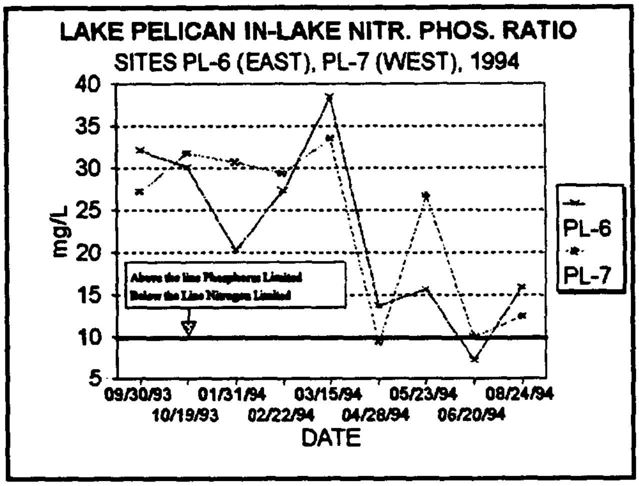


Figure 5. In-Lake N/P Ratio

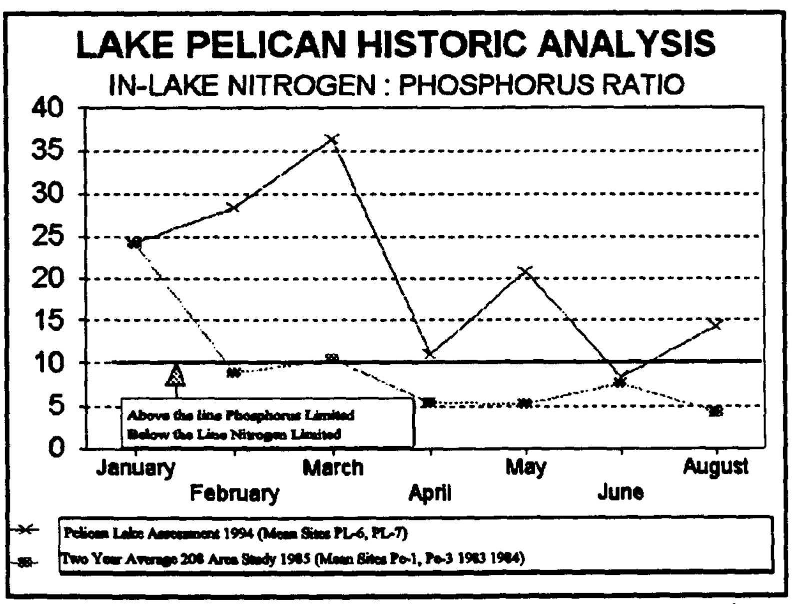


Figure 6. Historic In-Lake N & P Ratio

Historic Analysis

A 1985 Lake Kampeska/Pelican Lake Study (SD DWNR) established that Pelican Lake was a nitrogen limited system for most of the year, with the exception of January and March samples which indicated the only phosphorus limited periods (Figure 6). This is in direct contrast to the current Pelican Lake assessment project which showed the lake to be phosphorus limited for most of the year. This demonstrates a substantial change in the water chemistry of Pelican Lake over the past ten years.

FECAL COLIFORM BACTERIA

Fecal coliform bacteria can indicate fecal contamination, and thus potential human health hazards.

The in-lake fecal coliform bacteria results during the current assessment project were well within state standards and did not indicate potential health related problems (Figure 7). The lake appeared to assimilate above-standard inflows of fecal coliform bacteria from the tributary streams without any significant effects on in-lake bacteria levels.

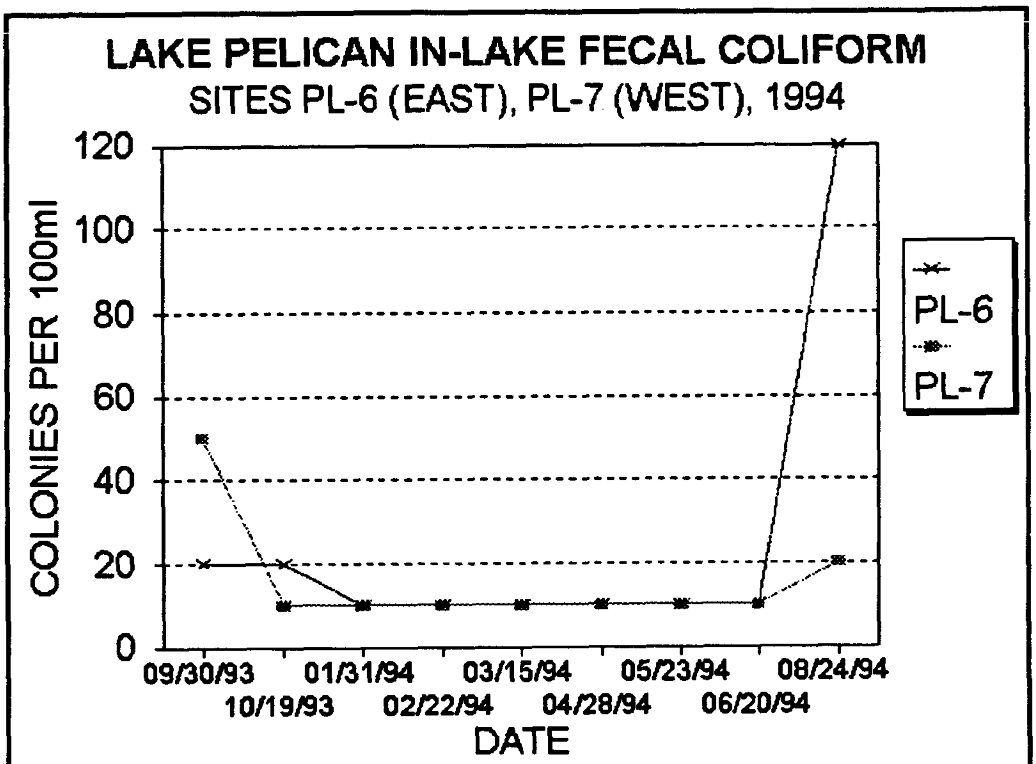


Figure 7. In-Lake Fecal Coliform Bacteria

Historic Analysis

Not enough data was available for an historic analysis of the fecal coliform bacteria parameter.

DISSOLVED OXYGEN

Dissolved oxygen levels in a lake vary according to growth and decomposition activities, air to water interfaces, and distribution by wind driven mixing. Oxygen levels less than 3.0 mg/L are stressful to aquatic invertebrates and most other aquatic organisms.

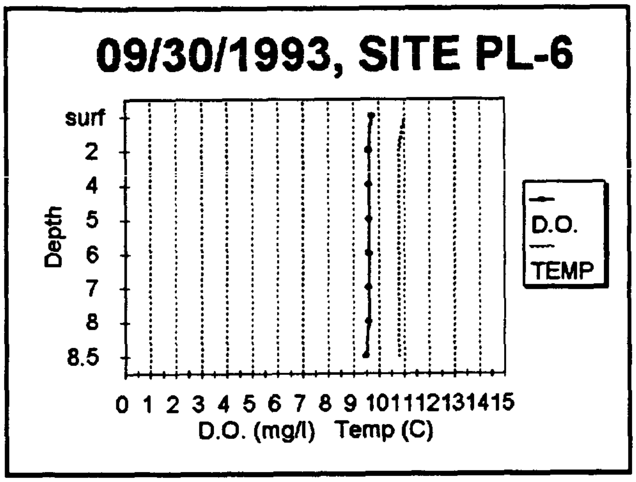
The dissolved oxygen levels in Pelican Lake occasionally dropped below the state water quality standard of 5.0 mg/L during the current assessment project. Figures 8 and 9 show dissolved oxygen and temperature profiles for the current sampling period. Samples were taken on a monthly basis from the two in-lake sampling sites, except November and December, 1993, when ice conditions were unsafe. Oxygen levels were measured at one-foot or two- foot intervals from the surface to bottom at each site.

In-lake dissolved oxygen stratification was sporadic and occurred most noticeably in August of 1994. Warm weather stratification was usually dependent upon periods of increased algal decomposition and periods of decreased wind action. Low oxygen levels were noted in January and February, 1994. These low levels were likely caused by the decay of organic material in the bottom sediments, and a lack of penetration by sunlight through the snow cover on the ice. Decreased light penetration resulted in less photosynthesis by algae and aquatic plants, causing them to give off less oxygen.

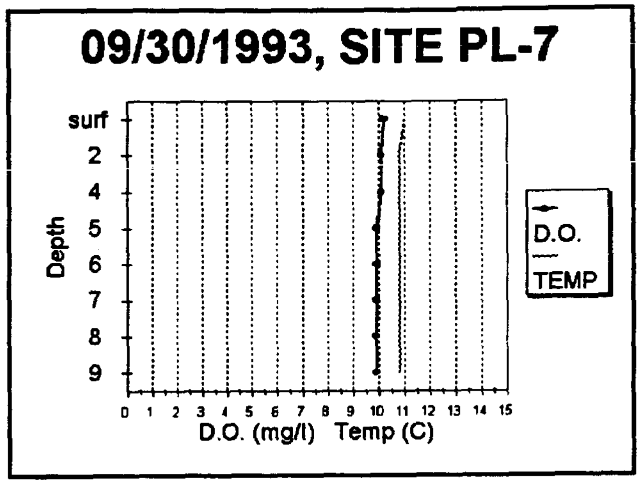
In-lake temperature stratification patterns were also observed during the winter months between January and March. This was a period of ice cover until the spring thaw, which increased inflow from the Big Sioux River in late March and April. The periods from March to July, and from August to October, were periods when the lake was mixed from top to bottom, allowing free chemical movement throughout the lake.

Figure 8. D.O. and temperature profiles, fall and winter.

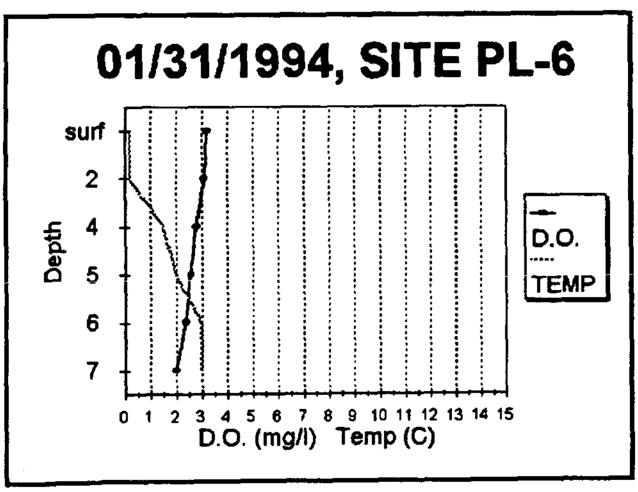
FALL



FALL



WINTER



WINTER

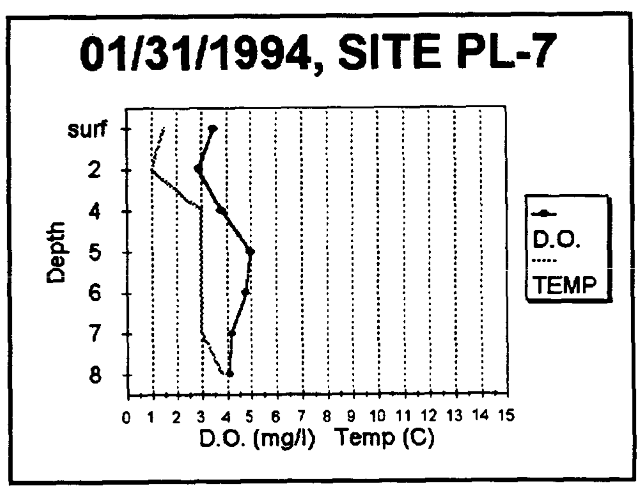
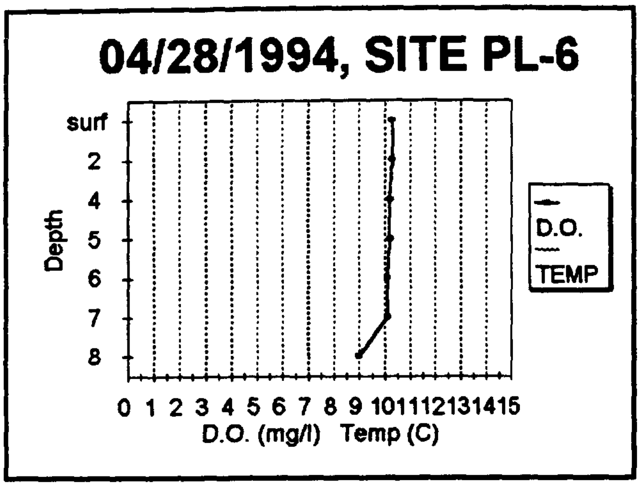
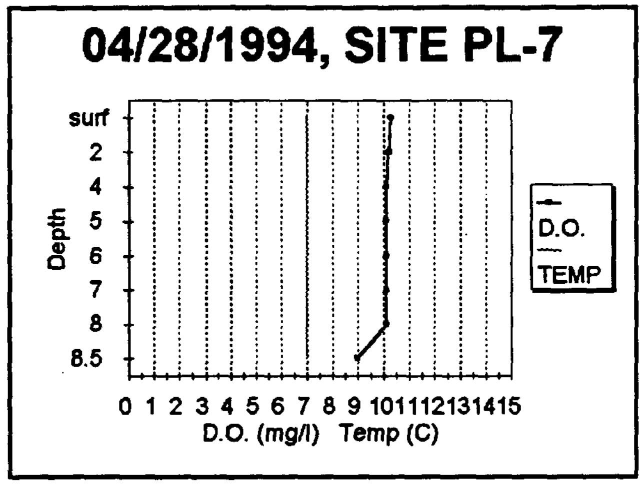


Figure 9. D.O. and temperature profiles, spring and summer.

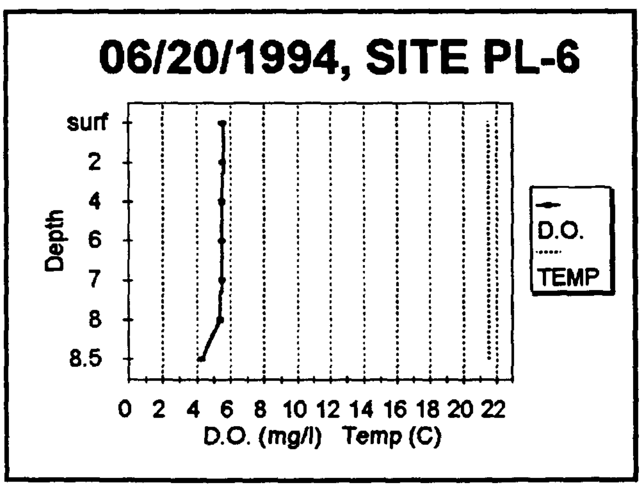
SPRING



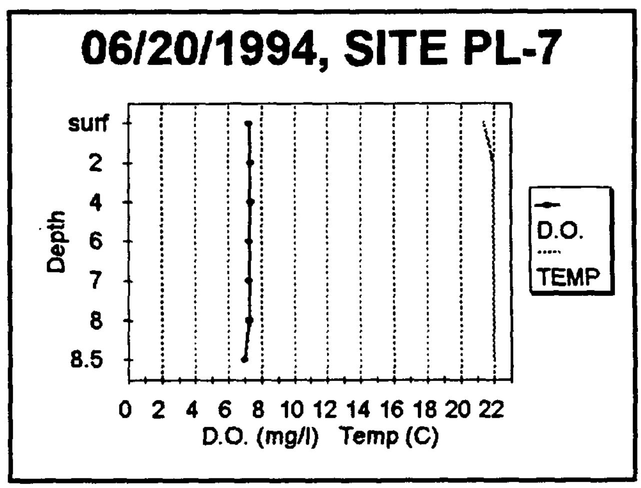
SPRING



SUMMER



SUMMER



pH

Field and laboratory pH is a measure of hydrogen ion activity in water. The pH scale is a number range between 1 and 14, with 7 being neutral. Any value less than 7 is considered acidic, and any value greater than 7 is considered basic. The pH range for most natural lakes is between 6 and 9. Deviation from a neutral pH of 7 is a result of the decomposition of salts as they react with water. Gases such as carbon dioxide, hydrogen sulfide, and ammonia also have a significant effect on pH. The pH level of a lake is directly related to the geography of the surrounding area.

During the current lake assessment, pH levels were within the state water quality standards of 6.5 to 9.0 units for all but one sample on September 30, 1993, at Site PL-7 (Figure 10). The result of 9.09 units slightly exceeded the upper pH standard of 9.0. This one variance does not represent a substantial problem for the overall in-lake chemistry of Pelican Lake. It should be noted, however, that the pH levels were generally more alkaline during warm water and runoff periods, and less alkaline during periods of cold water and ice cover.

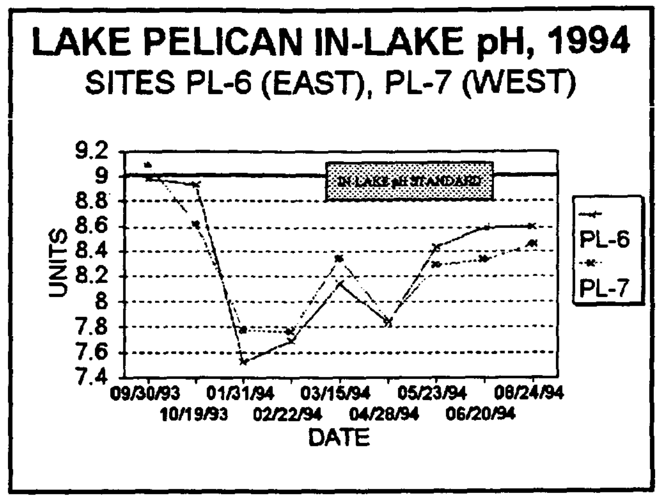


Figure 10. In-Lake pH

Historic Analysis

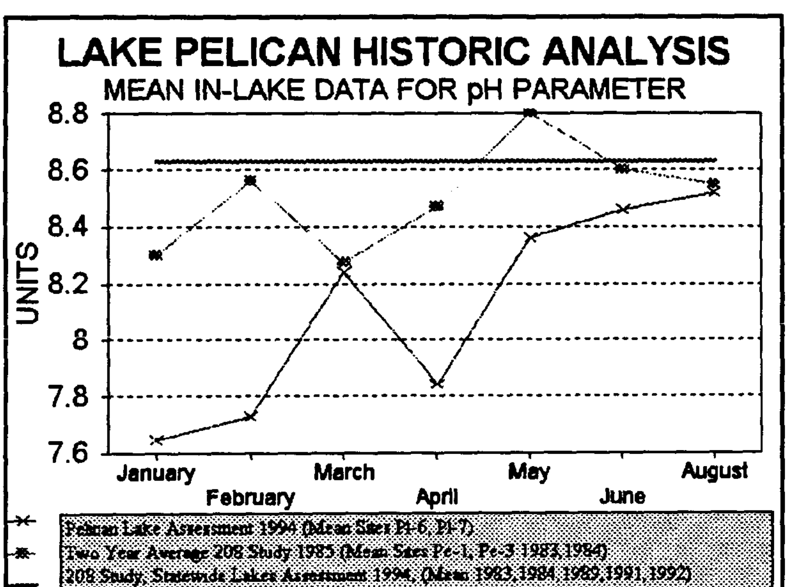


Figure 11. Historic In-Lake pH

An historic analysis of pH levels in Pelican Lake showed that the lake is remaining alkaline (Figure 11). The two- year average for the 1985 (208) study was more alkaline for all months than the current study results. In addition, all of the pH results in the 1993 SD Lakes Assessment Final Report were more alkaline than any of the pH levels measured during the current study period.

ALKALINITY

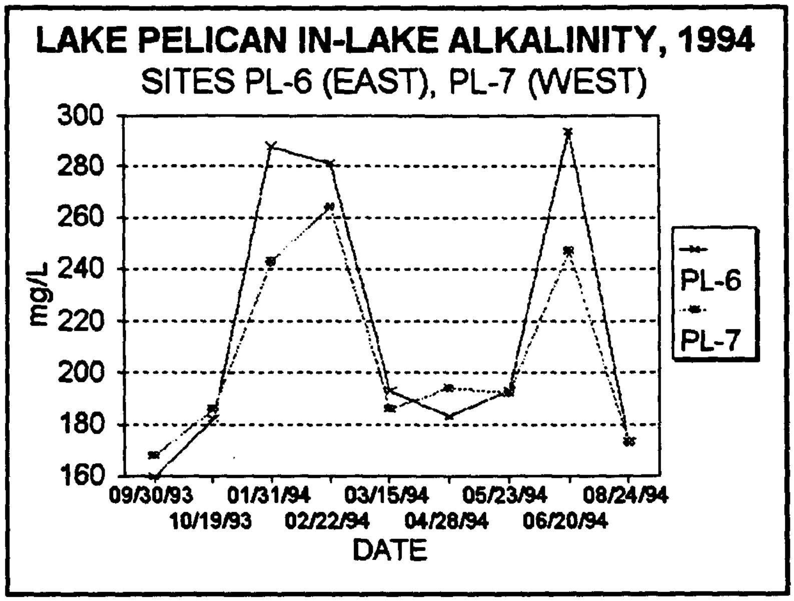


Figure 12. In-Lake Alkalinity

Alkalinity refers to the quantity of different compounds that shift the pH level of water to the alkaline side of neutrality. Alkalinity is generally the result of bicarbonates, but is expressed as a sum of hydroxide, carbonate, and bicarbonate. The contribution to alkalinity by hydroxides is rare in nature. Carbonate and bicarbonate, however, are common in water because carbonate minerals commonly occur in nature. Thus, the alkalinity of water is directly related to the geography of the area in which it occurs. The expected total alkalinities for water in nature generally range from 20 mg/L to 200 mg/L.

The alkalinity of Pelican Lake during the current lake assessment showed seasonal trends, with periods of low concentrations (Figure 12). Periods of low concentrations occurred during the fall of 1993 and the fall of 1994. An additional period of low concentrations occurred immediately after snowmelt runoff in the spring of 1994, and continued for approximately two months. These periods of variable concentrations may be attributed to inflows of ground water, or dilution from spring runoff water.

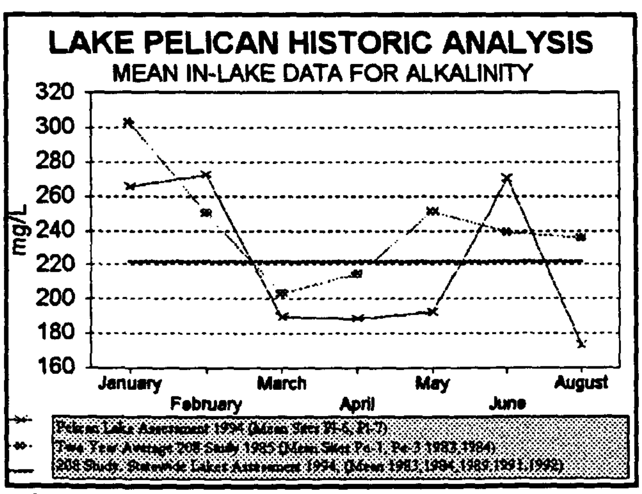


Figure 13. Historic In-Lake Alkalinity

Historic Analysis

Historic analysis showed no significant changes in seasonal patterns, or ranges of concentrations, compared to those observed during the current assessment (Figure 13).

TOTAL DISSOLVED SOLIDS

Total dissolved solids include salts and organic residue which pass through a filtered water sample. Total dissolved solids can be estimated by subtracting the amount of total suspended solids from the amount of total solids.

The total dissolved solids concentrations were within the state standard of <2500 mg/L during the current lake assessment sampling period (Figure 14). Greater concentrations of dissolved solids occurred during the winter months when ice cover prevented the wind from suspending bottom sediments. A period of low dissolved solids concentrations occurred immediately following the spring snowmelt runoff. This coincided with a dramatic increase in total suspended solids at the in-lake monitoring sites.

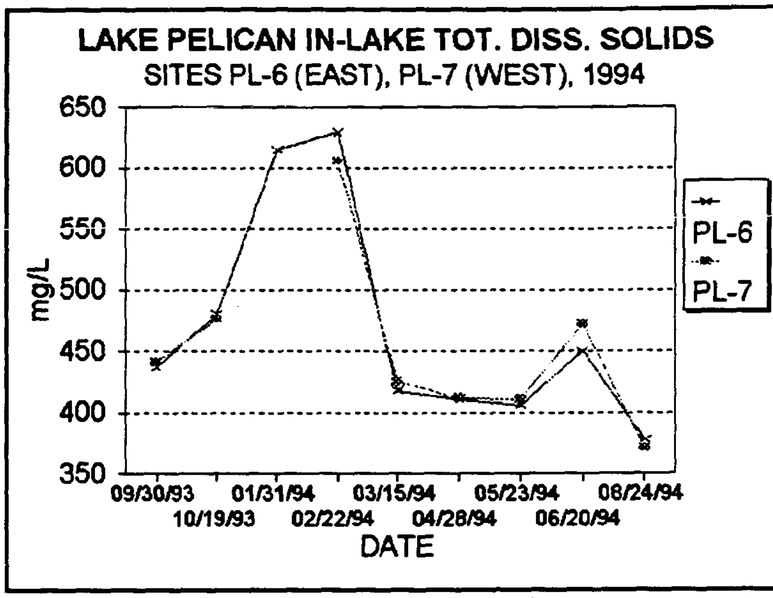


Figure 14. In-Lake Total Dissolved Solids

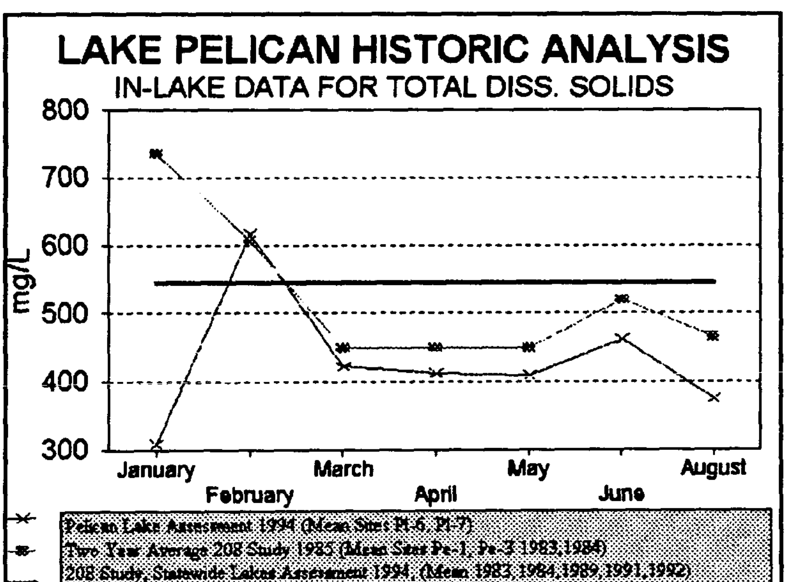


Figure 15. Historic In-Lake Total Dissolved Solids

Historic Analysis

An historic analysis of water quality data indicated only a minor variation in the seasonal trend for total dissolved solids (Figure 15). This variation occurred for the January mean sample results in which the 1985 (208) study showed significantly higher concentrations compared to the results for the current lake assessment project. The ranges for the means of all three baseline values, however, were very comparable.

TOTAL SUSPENDED SOLIDS

Total suspended solids include organic and inorganic materials that are not dissolved. This parameter can indicate the amount of sediment loading into a body of water and possible problems for the biological community. The suspended solids test does not include a measurement of larger particles which are moved along stream beds during high flow periods (bed load).

The total suspended solids parameter was used to measure the amount of sedimentation of Pelican Lake during the study period. Total suspended solids concentrations can be attributed to many factors. These factors include, but are not limited to: wind action, water depth, tributary loadings, shoreline erosion, and biological activity. Pelican Lake exhibited no thermal stratification during the study period. This allowed mixing throughout the entire water column, which caused wind action to directly influence total suspended solids concentrations.

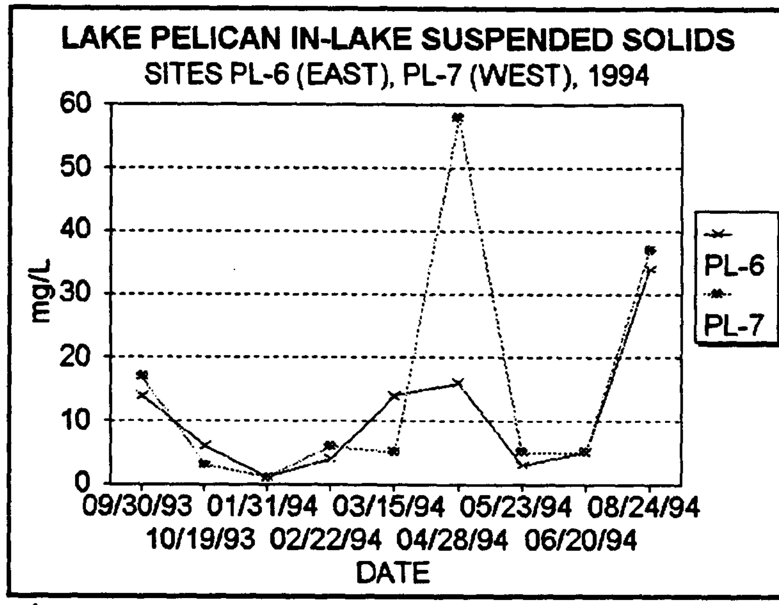


Figure 16. In-Lake Suspended Solids

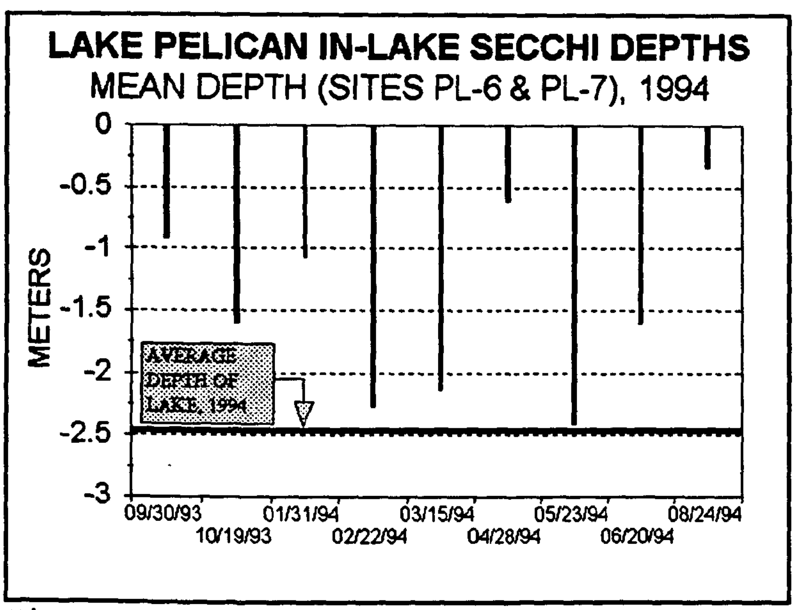


Figure 17. In-Lake Secchi Depths

The fluctuations in total suspended solids concentrations indicate that re-settling of solids and bound nutrients is a common occurrence in Pelican Lake. A seasonal trend is evidenced only by an increase in concentrations of total suspended solids during and immediately following snowmelt runoff (Figure 16).

Total suspended solids concentrations have a direct influence on water clarity in Pelican Lake. Water clarity was monitored during the study period by taking measurements of Secchi disk readings (Figure 17).

The depth at which a Secchi disk can be seen is a function of the reflection of light from the water's surface. The reflection of light is in turn influenced by the absorption characteristics of the water, and the amount of dissolved and particulate matter in the water. The deepest Secchi disk readings were obtained during periods of low total suspended solids concentrations. These periods occurred during both cold and warm water months.

Historic Analysis

An historic analysis of total suspended solids data indicated very little variation in range or seasonal trends (Figure 18).

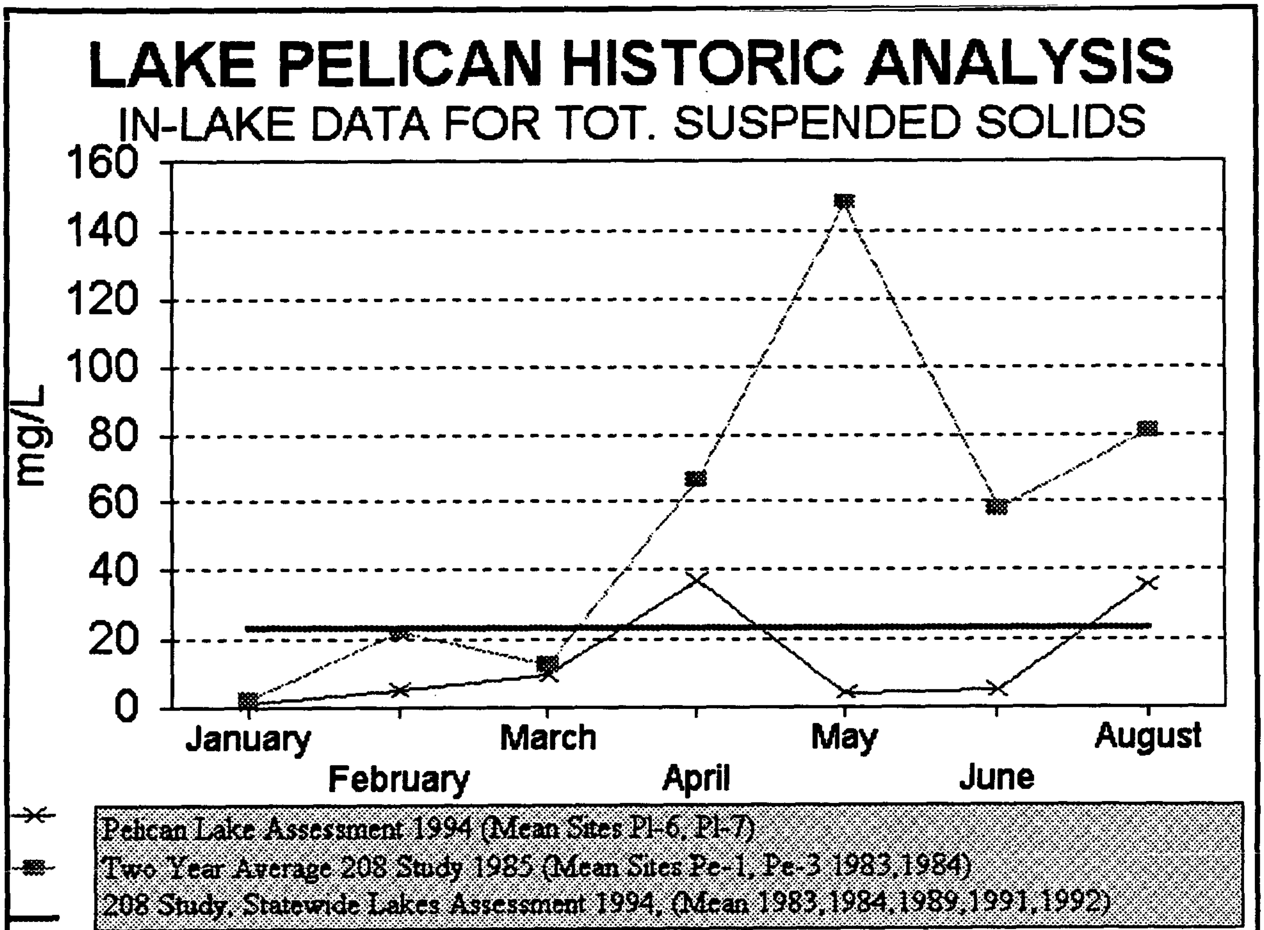


Figure 18. Historic In-Lake Suspended Solids

NUTRIENT PARAMETERS

A comparison of nutrient parameters (nitrogen and phosphorus) not only illustrates differences in concentration ranges, but also indicates similarities in seasonal trends. Seasonal trends for nitrates and phosphates show that increases and decreases in concentrations for both parameters occur simultaneously (Figure 19).

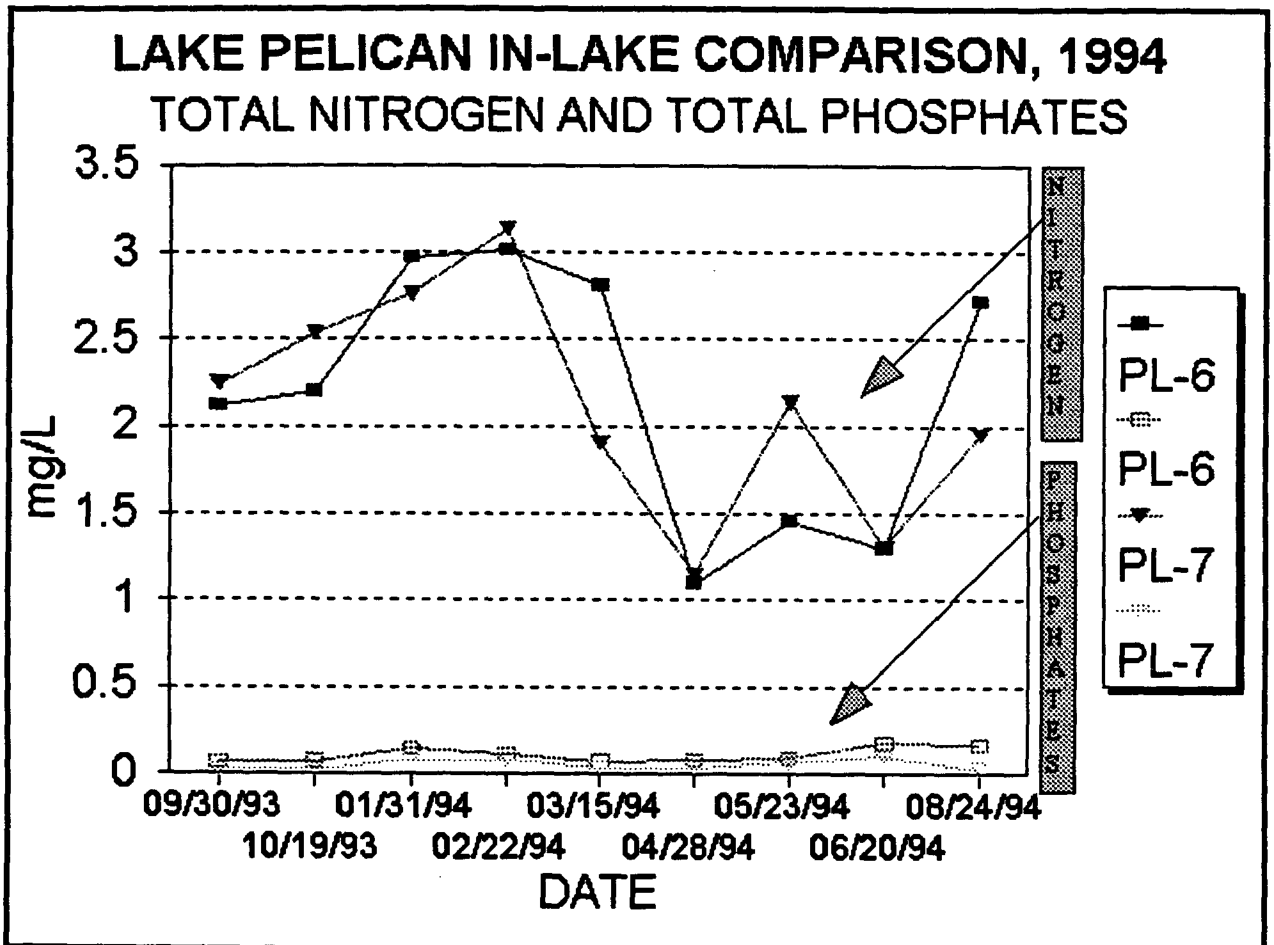


Figure 19. In-Lake Comparison of Total Nitrogen and Total Phosphates

AMMONIA

Ammonia is generated by bacteria as a primary end product of the decomposition of organic matter. Ammonia is a form of nitrogen which is directly available to plants as a nutrient for growth. High ammonia concentrations can demonstrate organic pollution.

The ammonia levels in Pelican Lake fluctuated greatly during the study period (Figure 20). The highest concentrations occurred during the cold water months when the biological breakdown of nitrogen molecules by bacteria produced large amounts of ammonia. Snowmelt runoff also contributed large amounts of available ammonia, but a corresponding increase in algae and plant growth reduced the concentrations of ammonia in the lake.

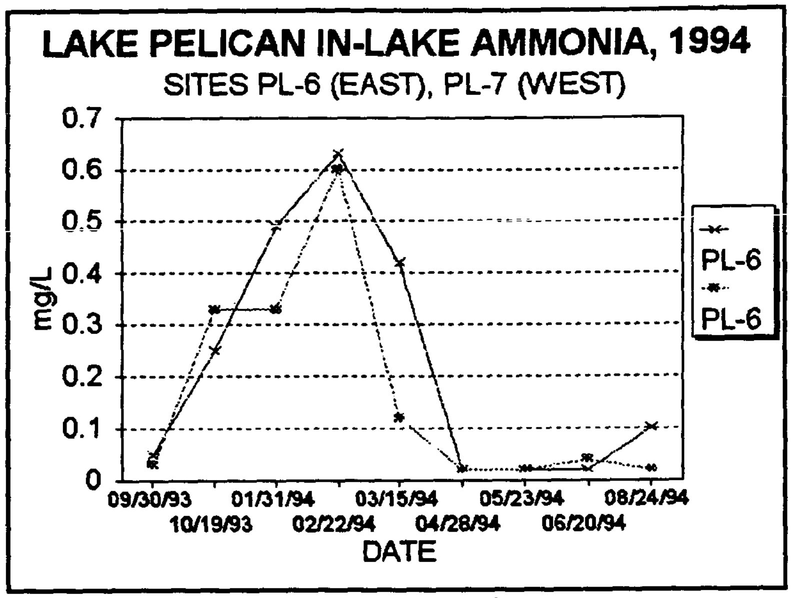


Figure 20. In-Lake Ammonia

Historic Analysis

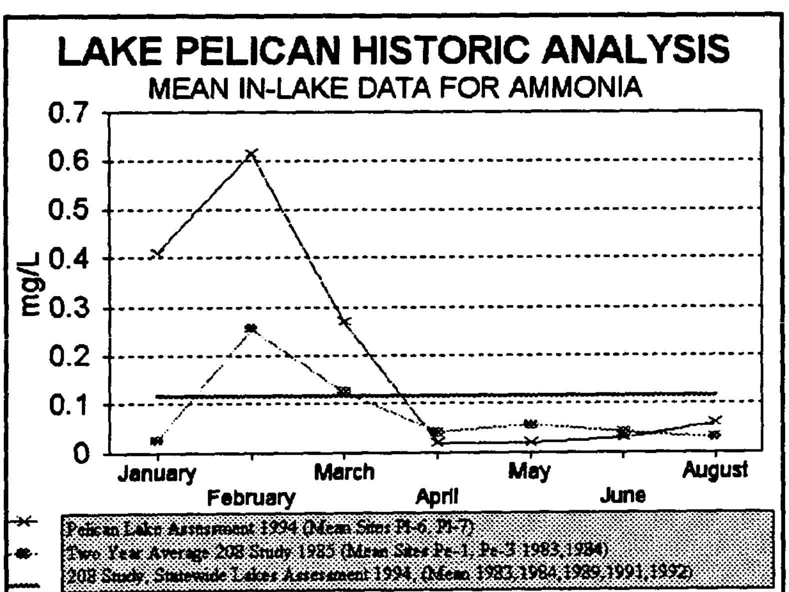


Figure 21. Historic In-Lake Ammonia

An historic analysis of ammonia levels in Pelican Lake revealed little variation in seasonal trends or ranges of concentrations for this parameter (Figure 21).

TOTAL KJELDAHL NITROGEN

Total Kjeldahl nitrogen (TKN) is used to measure both total nitrogen and organic nitrogen. The amount of ammonia (inorganic) is subtracted from total Kjeldahl nitrogen to determine the amount of organic nitrogen present. Organic forms of nitrogen can be broken down into different compounds which are used by phytoplankton (small plants having no or very limited powers of locomotion). Organic nitrogen can be released from living macrophytes, and large quantities can also be released from decaying macrophytes.

The in-lake total Kjeldahl nitrogen values fluctuated greatly during the assessment period (Figure 22). The amount of TKN increased during cold water periods, when floating and submergent vegetation died and decomposed by bacteriological activity. A decrease in TKN concentrations following snowmelt runoff indicated the incorporation of TKN into both the biota and sediment of Pelican Lake.

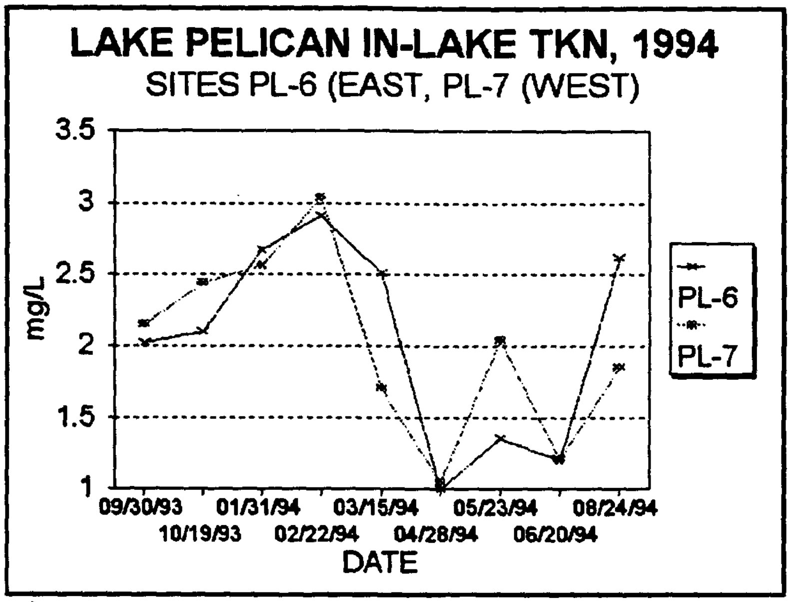


Figure 22. In-Lake TKN

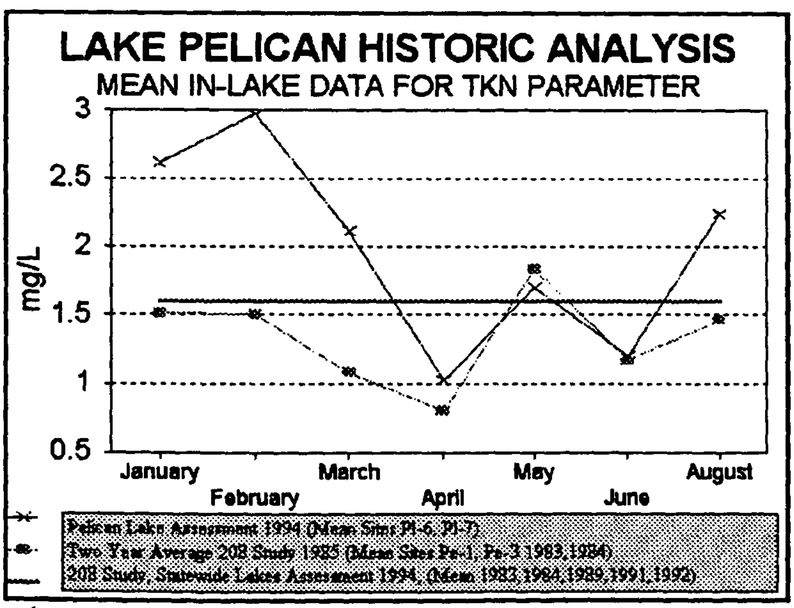


Figure 23. Historic In-Lake TKN

Historic Analysis

An historic analysis of total Kjeldahl nitrogen showed little variation in seasonal trends or ranges of concentrations over time (Figure 23).

NITRATE + NITRITE

Nitrate is often the most abundant form of inorganic nitrogen, and it is readily assimilated by algae and larger hydrophytes. In natural waters, nitrate concentrations are usually low, around 0.1 mg/L. Some sources of inorganic nitrogen are agricultural activities, sewage, and atmospheric pollution.

Nitrate + nitrite levels were stable at 0.10 mg/L, which was the laboratory detection limit, for all but two sample dates (Figure 24). The first variation occurred on January 31, 1994. An identical spike occurred during snowmelt runoff. These two peaks in inorganic nitrogen do not correlate to increases of any other form of nitrogen monitored during the study period.

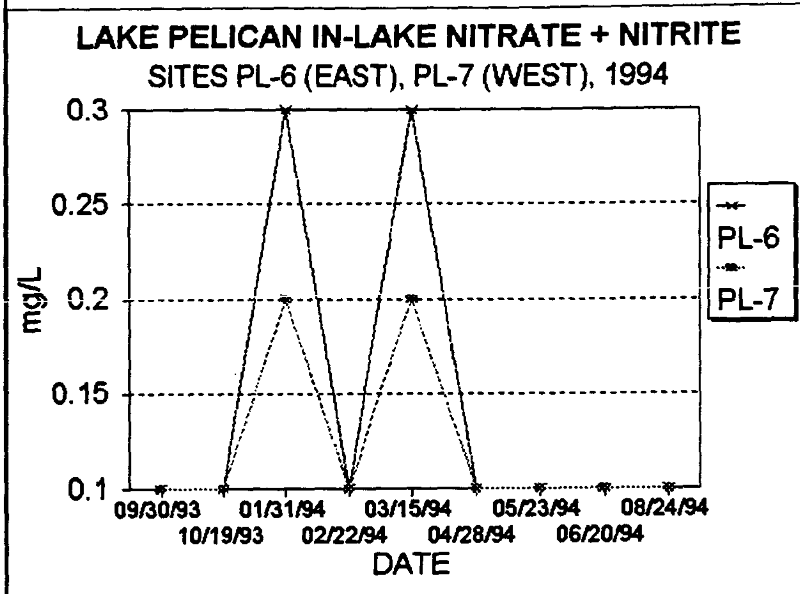


Figure 24. In-Lake Nitrate + Nitrite

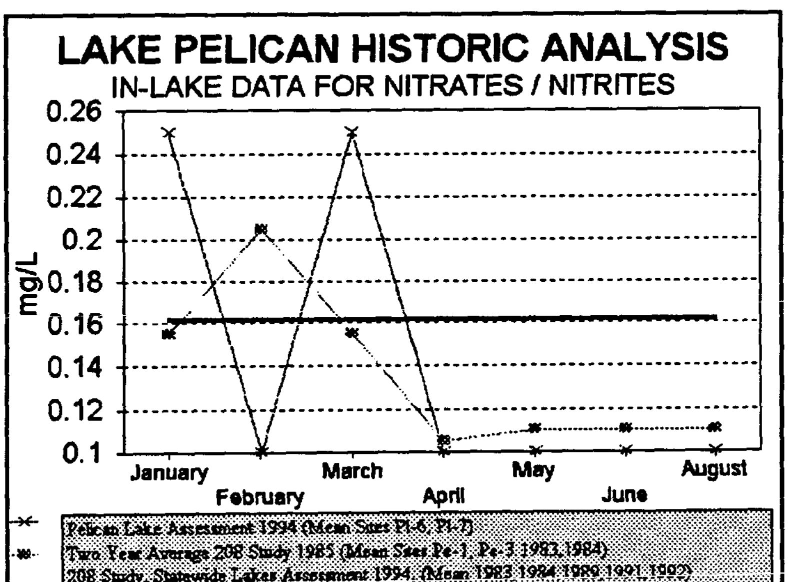


Figure 25. Historic In-Lake Nitrate + Nitrite

Historic Analysis

Historic analysis, as shown, indicated only minor changes in range or concentration for nitrate + nitrite. However, seasonal trends during the current assessment did vary (January to March) conversely to historic trends (Figure 25).

TOTAL PHOSPHORUS

The analysis of total phosphorus measures all of the phosphorus present in water samples. Phosphorus is an element which is essential for all living things. However, not all forms of phosphorus are immediately available to aquatic plants and algae. For example, phosphorus can adhere to soil, causing it to be released only when oxygen levels are depleted. Nevertheless, when phosphorus concentrations are high, nuisance growths of aquatic plants and algae may result. Sources of phosphorus include agricultural activities, sewage, and the decomposition of organic matter.

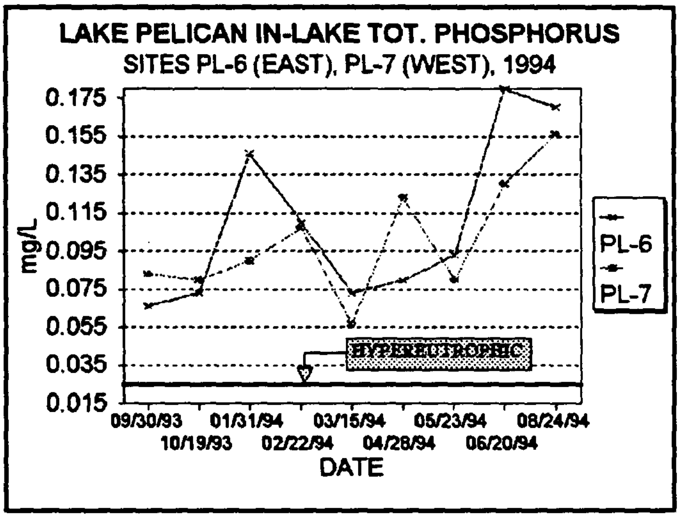


Figure 26. In-Lake Total Phosphorus

During the current assessment, total phosphorus concentrations in Pelican Lake demonstrated no discernable seasonal trends (Figure 26). The results for the two in-lake sites did, however, reveal significant differences on several sample dates. In addition, all sample results were above the hypereutrophic level (Wetzel, 1983). The general trend for total phosphorus over the study period was a steady increase in concentration. The most significant increase of in-lake total phosphorus occurred after the May 23, 1994, sample date. This reflects an increase of total phosphorus loadings to the lake following watershed storm events as shown in (Figure 64. (Daily Total Phosphorus Loads, Inflow)).

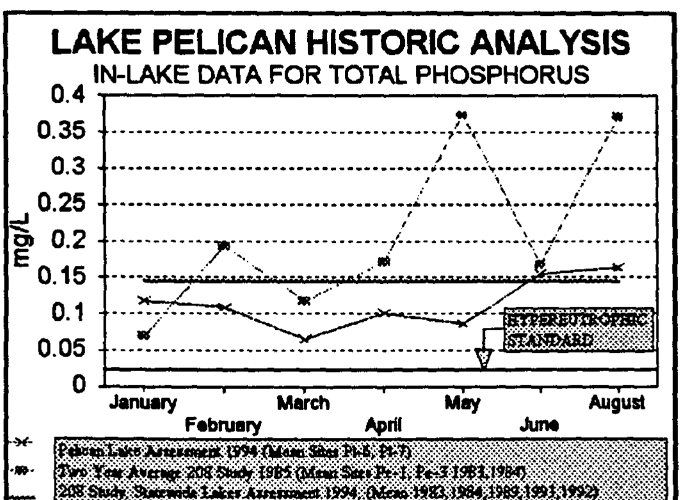


Figure 27. Historic In-Lake Total Phosphorus

Historic Analysis

The historic analysis of this parameter showed a significant decrease in total phosphorus concentrations over the last ten year period (Figure 27) . This may be a reflection of conservation practices promoted by the Natural Resources Conservation Service, local landowners, and other conservation groups. This downward trend in phosphorus levels may also help to explain the shift from nitrogen to phosphorus limitation for the lake. In spite of an overall decrease, phosphorus concentrations are still well above the hypereutrophic level, as shown.

TOTAL DISSOLVED PHOSPHORUS

During the current assessment, total dissolved phosphorus concentrations showed a sharp increase in January and February of 1994 (Figure 28). By contrast, there is a sharp decrease in the total dissolved phosphorus concentration during and immediately following snowmelt runoff. This could indicate that total dissolved phosphorus is being incorporated into the biota of the lake, or that it is being bound into the sediments. Another increase in total dissolved phosphorus occurred during June, 1994. This could be the result of increased loadings to Pelican Lake from the tributary stream sites. However, this additional total dissolved phosphorus decreased rapidly, indicating that it was taken up by algae and other aquatic plants.

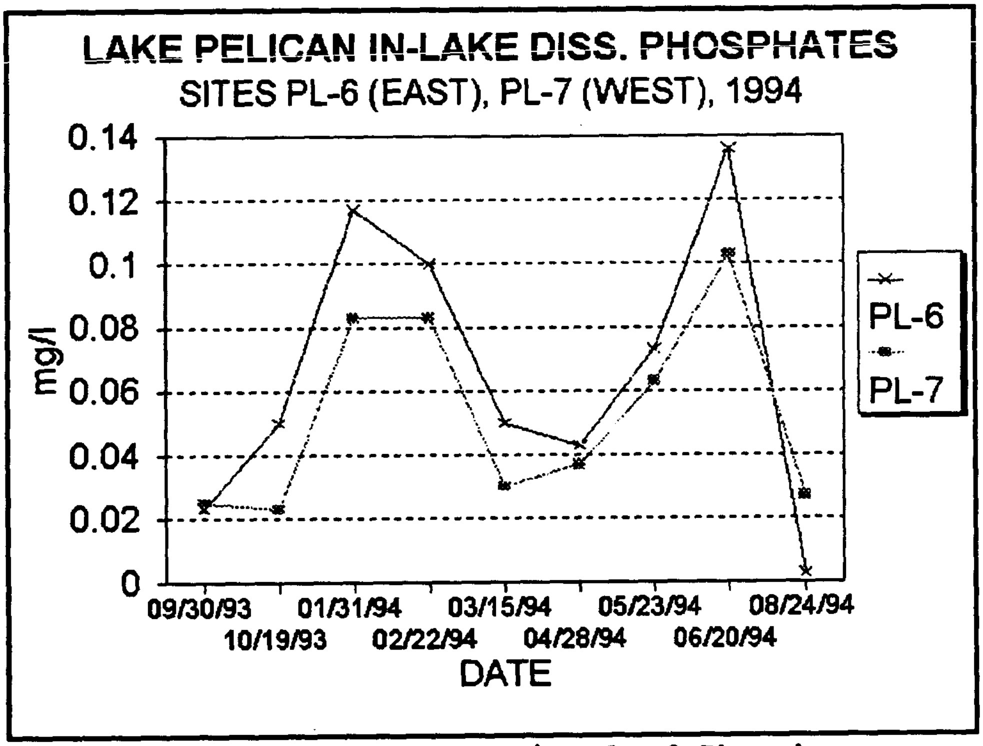


Figure 28. In-Lake Total Dissolved Phosphorus

Historic Analysis

There was not enough data to do an historic analysis of total dissolved phosphorus.

SAMPLE DATA FOR SITE 6 (In-Lake East), 1994

DATE	TIME	SAMP	SITE	WTEMP C	AIR TEMP C	DISOX mg/l	SECCHI FT	SECCHI METERS	FECAL COLIFORM per 100ml	LAB pH	TALKAL -M mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	AMMON mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4 mg/l	TDPO4 mg/l
09/30/93	1015	GRAB	PL-6			9.7	3	0.9	20	8.98	160	451	437	14	0.05	0.1	2.02	0.066	0.023
10/19/93	1430	GRAB	PL-6	10.3	15	9.8	6	1.8	20	8.93	182	486	480	6	0.25	0.1	2.1	0.073	0.050
01/31/94	1045	GRAB	PL-6	0.2	-18	3.2	3	0.9	10	7.52	288	616	615	1	0.49	0.3	2.67	0.146	0.117
02/22/94	1130	GRAB	PL-6	0.1	0	3.8	7.2	2.2	10	7.69	281	633	629	4	0.63	0.1	2.91	0.110	0.100
03/15/94	1500	GRAB	PL-6	1	1.5	13.2	7	2.1	10	8.14	193	432	418	14	0.42	0.3	2.51	0.073	0.050
04/28/94	1000	GRAB	PL-6	7	4	10.3	2.5	0.8	10	7.83	183	427	411	16	0.02	0.1	1	0.080	0.043
05/23/94	1145	GRAB	PL-6	21	22	7	7.8	2.4	10	8.43	193	409	406	3	0.02	0.1	1.36	0.093	0.073
06/20/94	1515	GRAB	PL-6	21.4	22	7.3	5.5	1.7	10	8.59	294	455	450	5	0.02	0.1	1.2	0.180	0.136
08/24/94	1215	GRAB	PL-6	22.2	27	9	1	0.3	120	8.59	173	412	378	34	0.1	0.1	2.62	0.170	0.003
MINIMUM				0.1	-18	3.2	1	0.3	10	7.52	160	409	378	1	0.02	0.1	1	0.066	0.003
MAXIMUM				22.2	27	13.2	7.8	2.4	120	8.98	294	633	629	34	0.63	0.3	2.91	0.180	0.136
MEAN				10.4	9	8.2	4.8	1.5	24	8.30	216	480	469	11	0.22	0.1	2.04	0.110	0.066

SAMPLE DATA FOR SITE 7 (In-Lake West), 1994

DATE	TIME	SAMP	SITE	WTEMP C	AIR TEMP C	DISOX mg/l	SECCHI FT	SECCHI METERS	FECAL COLIFORM per 100ml	LAB pH	TALKAL -M mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	AMMON mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4 mg/l	TDPO4 mg/l
09/30/93	1045	GRAB	PL-7	11	13	10.2	3	-0.9	50	9.09	168	458	441	17	0.03	0.1	2.15	0.083	0.025
10/19/93	1530	GRAB	PL-7	10.3	15	6.4	4.5	-1.4	10	8.61	186	479	476	3	0.33	0.1	2.44	0.08	0.023
01/31/94	1230	GRAB	PL-7	1.5	-18	3.5	4	-1.2	10	7.77	243			1	0.33	0.2	2.56	0.09	0.083
02/22/94	1100	GRAB	PL-7	1.3	0	2.4	7.7	-2.3	10	7.76	264	612	606	6	0.6	0.1	3.04	0.107	0.083
03/15/94	1430	GRAB	PL-7	3	1	11.4	7	-2.1	10	8.34	186	430	425	5	0.12	0.2	1.71	0.057	0.03
04/28/94	1030	GRAB	PL-7	7	2	10.3	1.5	-0.5	10	7.85	194	470	412	58	0.02	0.1	1.05	0.123	0.037
05/23/94	1130	GRAB	PL-7	22	24	6.2	8	-2.4	10	8.29	192	416	411	5	0.02	0.1	2.04	0.08	0.063
06/20/94	1445	GRAB	PL-7	21.5	22	5.6	5	-1.5	10	8.33	247	477	472	5	0.04	0.1	1.21	0.13	0.103
08/24/94	1145	GRAB	PL-7	23	26	8.8	1.2	-0.4	20	8.45	173	408	371	37	0.02	0.1	1.85	0.156	0.027
MINIMUM				1.3	-18	2.4	1.2	-0.4	10	7.76	168	408	0	1	0.02	0.1	1.05	0.057	0.023
MAXIMUM				23	26	11.4	8	-2.4	50	9.09	264	612	606	58	0.60	0.2	3.04	0.156	0.103
MEAN				11.2	9	7.2	4.7	-1.4	16	8	206	469	402	15	0.17	0.1	2.01	0.101	0.053

CARLSON: TROPHIC STATE INDEX (TSI)

The Carlson Trophic State Index (TSI) is an indicator which can be used to measure relative trophic states for bodies of water. A trophic state index is calculated from several equations using total phosphorus, Secchi disk, and chlorophyll *a* measurements. The resulting values are combined and a mean value is calculated for total phosphorus, Secchi depth, and chlorophyll *a*. The mean TSI's for each sampling date are averaged to arrive at a single mean TSI number for a lake for one year. The Carlson Index results, which were used to determine the trophic status of Pelican Lake, are shown in Figure 29.

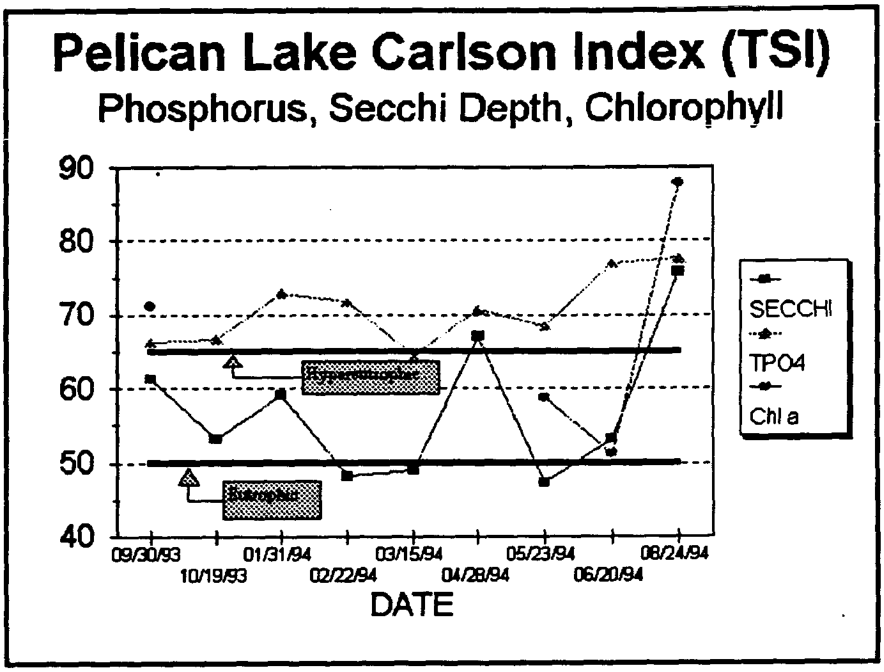


Figure 29. In-Lake Carlson Index

Chlorophyll *a* analyses were conducted as a part of the Pelican Lake assessment project because of their primary importance in plant production. Measurements of photosynthetic pigments have been widely used to quantify phytoplankton standing crops, and to measure in-lake water quality. Chlorophyll *a* is the pigment of choice since it is normally the most important pigment in living material and because it has been studied extensively. Chlorophyll in the Pelican Lake system was measured mainly to serve as a dependant variable in regression analysis of the lake system. It is a trophic state variable that characterizes the response of the lake system (level of productivity) to other variables such as phosphorus loadings, which are subject to watershed management. This response to external forces allows a linkage between activities in the watershed and in-lake water quality.

Chlorophyll was analyzed for four sample dates for the in-lake sites, PL-6 (East) and PL-7 (West). The first three samples were filtered using standard grade filter membranes, while the last sample was filtered using a glass fiber filter. The chlorophyll results for the last sample were considerably higher, indicating that glass fiber filters may provide a better filter medium. The lower concentrations for the first three sample dates had a corresponding effect of lowering the mean chlorophyll TSI values for those dates.

The mean TSI values for Pelican Lake during the study period were 71.34 for phosphorus, 54.76 for Secchi disk measurements, and 67.28 for chlorophyll *a*. These values resulted in an overall mean TSI of 64.46. These four TSI values can be compared to the TSI values for other lakes in South Dakota in Tables 7, 8, 9, and 10 (Unmodified Trophic State Indices Rankings, 1993 South Dakota Lakes Assessment Final Report, SD DENR, 1994).

The Carlson Index uses TSI levels of 65 and greater to denote hypereutrophic bodies of water, while values of 50 to 64 indicate eutrophic bodies of water. The TSI values for Pelican Lake exceeded the hypereutrophic level for 8 out of 9 samples using the phosphorus index, and the eutrophic level was exceeded for 6 out of 9 samples using the Secchi disk index (Figure 29). In two instances, the Secchi disk measurement also exceeded the hypereutrophic level. In one of these instances, the elevated Secchi disk TSI measurement was due to a high level of suspended solids as a result of ice out. The other high TSI value was due to an algae bloom that occurred in early August, 1994.

Shown below is a comparison of the TSI values reported in the 1993 South Dakota Lakes Assessment Final Report (1992 values) versus the TSI values from the current assessment:

	Phosphorus TSI	Secchi Depth TSI	Chlorophyll a TSI
1992 Values	69.54	60.29	67.29
Current Assessment	71.34	54.76	67.28

Based on this comparison, Pelican Lake was found to be more eutrophic in terms of phosphorus during the current assessment, and less eutrophic in terms of Secchi depth. Current results for chlorophyll *a* were similar to TSI values found in the 1993 South Dakota Lakes Assessment Final Report.

Table 7. MEAN TROPHIC STATE INDICES RANKING

Below are the rankings of the assessment lakes by averaging the Carlson's TSI ranking for secchi depth, total phosphorus concentrations, and chlorophyll concentrations. The lakes are ranked from hyper-eutrophic to oligotrophic.

1	Preston, Lake	90.48	56	Mitchell, Lake	68.32
2	Dewberry Lake	87.26	57	Punished Woman's Lake	67.58
3	School Lake	87.00	58	Bismark Lake	67.41
4	Sully Lake	84.22	59	Platte, Lake	67.06
5	Burke Lake	83.54	60	Center Lake	66.75
6	Whitewood Lake	83.47	61	Amsden Dam	66.71
7	Redfield Lake	83.38	62	Murdo Dam	66.22
8	Kampeska, Lake	82.34	63	Richmond Lake	65.75
9	Byron, Lake	81.72	64	Pelican Lake	65.71
10	Mina Lake	79.76	65	Jones Lake	65.60
11	New Wall Lake	79.49	66	Sylvan Lake	65.55
12	Andes, Lake	79.12	67	Loyalton Dam	65.28
13	East Oakwood Lake	78.97	68	Norden, Lake	65.16
14	Academy Lake	78.90	69	Rosehill Lake	65.11
15	Dante Lake	78.49	70	Campbell, Lake (Campbell)	65.02
16	Corsica Lake	78.01	71	Hanson, Lake	64.97
17	Thompson, Lake	77.69	72	Sully Dam	64.75
18	Campbell, Lake (Brookings)	77.59	73	Waggoner Lake	64.47
19	Beaver Lake	77.38	74	McCook Lake	64.28
20	Henry, Lake	77.08	75	South Buffalo Lake	64.23
21	Swan Lake	77.03	76	Nine Mile Lake	63.97
22	Cottonwood Lake (Spink)	76.84	77	Pierpont Lake	63.53
23	Hendricks, Lake	76.42	78	East Vermillion Lake	63.32
24	Flat Creek Dam	76.38	79	Bullhead Lake	62.78
25	Faulkton, Lake	76.32	80	Big Stone Lake	62.38
26	Geddes Lake	76.24	81	Horsethief Lake	62.18
27	Ravine Lake	75.95	82	Minnewasta Lake	61.99
28	Carthage, Lake	75.64	83	Newell Lake	61.91
29	Albert, Lake	75.48	84	Lakota, Lake	61.72
30	Cottonwood Lake, (Sully)	74.40	85	Fate Dam	61.22
31	Hiddenwood, Lake	74.22	86	Brakke Lake	60.96
32	Rahn Dam	74.02	87	Roy Lake	60.91
33	Wall Lake	73.51	88	Marindahl Lake	60.84
34	Fish Lake	72.81	89	Isabell, Lake	60.81
35	Rosette Lake	72.60	90	Twin Lakes	60.15
36	Pocasse, Lake	72.40	91	Stockade Lake	60.12
37	Herman, Lake	72.22	92	Brant Lake	60.05
38	Silver Lake	72.07	93	South Red Iron Lake	59.38
39	Madison, Lake	71.94	94	Legion Lake	58.51
40	Traverse, Lake	71.44	95	Freeman Lake	58.45
41	Clear Lake (Duel)	71.33	96	Shadehill Reservoir	56.47
42	Wilmarth Lake	71.32	97	Newell City Pond	55.90
43	Coal Springs Dam	70.82	98	Sheridan Lake	55.31
44	Covell Lake	70.78	99	Cochrane, Lake	54.94
45	Blue Dog Lake	70.67	100	Canyon Lake	53.96
46	Bierman Gravel Pit	70.28	101	Clear Lake (Marshall)	53.19
47	Alice, Lake	70.23	102	Iron Creek Lake	52.92
48	Louise, Lake	70.16	103	Yankton, Lake	52.81
49	Cresbard Lake	70.13	104	Orman Dam	48.01
50	Hayes Lake	69.87	105	Pickerel Lake	47.87
51	Elm Lake	69.82	106	Enemy Swim Lake	45.10
52	White Lake Dam	69.75	107	Angostura Reservoir	43.75
53	Roosevelt Lake	69.00	108	Deerfield Lake	39.37
54	Alvin, Lake	68.83	109	Cold Brook Reservoir	38.11
55	Poinsett, Lake	68.59	110	Pactola Reservoir	35.44

Table 8. SECCHI DEPTH TROPHIC STATE INDICES RANKING

Below are the rankings of the assessment lakes by Carlson's TSI for secchi depth. The lakes are ranked from hyper-eutrophic to oligotrophic.

1	Dewberry Lake	93.22	56	Sylvan Lake	61.53
2	School Lake	90.36	57	Center Lake	61.29
3	Coal Springs Dam	87.14	58	Nine Mile Lake	61.29
4	New Wall Lake	85.93	59	Cottonwood Lake (Spink)	60.70
5	Flat Creek Dam	78.66	60	Pelican Lake	60.29
6	Whitewood Lake	77.63	61	Alvin, Lake	59.59
7	Blue Dog Lake	77.14	62	South Red Iron Lake	59.07
8	Burke Lake	77.14	63	Pocasse, Lake	58.07
9	Dante Lake	77.14	64	Bismark Lake	57.82
10	East Oakwood Lake	77.14	65	Roy Lake	57.65
11	Andes, Lake	75.99	66	Roosevelt Lake	57.14
12	Hayes Lake	75.99	67	Yankton, Lake	57.14
13	Mina Lake	75.15	68	Orman Dam	57.06
14	Swan Lake	75.15	69	Amsden Dam	56.84
15	Henry, Lake	75.12	70	Academy Lake	56.78
16	Beaver Lake	74.39	71	Jones Lake	56.61
17	Byron, Lake	73.22	72	Norden, Lake	56.55
18	Campbell, Lake (Brookings)	73.22	73	Lakota, Lake	56.44
19	Hendricks, Lake	73.22	74	Silver Lake	55.71
20	Corsica Lake	72.86	75	Legion Lake	55.57
21	Geddes Lake	71.70	76	Shadehill Reservoir	55.55
22	Newell Lake	71.62	77	Murdo Dam	55.44
23	Alice, Lake	71.29	78	Mitchell, Lake	55.16
24	Ravine Lake	70.91	79	Loyalton Dam	54.97
25	Kampeska, Lake	70.00	80	Brant Lake	54.21
26	Fish Lake	69.73	81	Horsethief Lake	54.21
27	Punished Woman's Lake	69.71	82	Freeman Lake	54.16
28	Carthage, Lake	69.41	83	Minnewasta Lake	53.86
29	Traverse, Lake	69.23	84	East Vermillion Lake	53.73
30	Sully Lake	69.07	85	Waggoner Lake	53.57
31	Richmond Lake	68.66	86	Wilmarth Lake	53.39
32	Redfield Lake	68.62	87	Marindahl Lake	53.14
33	Rosette Lake	68.40	88	Cochrane, Lake	53.02
34	Hiddenwood, Lake	67.75	89	Poinsett, Lake	52.97
35	Covell Lake	67.51	90	Pierpont Lake	52.55
36	Elm Lake	67.44	91	Cottonwood Lake, (Sully)	52.55
37	White Lake Dam	67.44	92	Canyon Lake	51.59
38	Herman, Lake	67.31	93	Sheridan Lake	51.29
39	Wall Lake	67.14	94	Clear Lake (Marshall)	50.90
40	Clear Lake (Duel)	67.13	95	Louise, Lake	49.59
41	South Buffalo Lake	66.21	96	Cresbard Lake	49.43
42	Bullhead Lake	66.10	97	Stockade Lake	48.59
43	Fate Dam	64.21	98	Platte, Lake	48.57
44	Twin Lakes	64.21	99	Rosehill Lake	48.56
45	Faulkton, Lake	64.18	100	McCook Lake	48.43
46	Hanson, Lake	63.81	101	Isabell, Lake	46.63
47	Thompson, Lake	63.69	102	Iron Creek Lake	45.92
48	Sully Dam	63.64	103	Pickerel Lake	45.30
49	Brakke Lake	63.47	104	Enemy Swim Lake	44.49
50	Bierman Gravel Pit	63.36	105	Angostura Reservoir	43.65
51	Madison, Lake	63.19	106	Deerfield Lake	37.54
52	Big Stone Lake	62.49	107	Pactola Reservoir	35.59
53	Rahn Dam	62.43	108	Cold Brook Reservoir	29.61
54	Newell City Pond	62.24	109	Campbell, Lake (Campbell)	NA
55	Albert, Lake	61.78	110	Preston, Lake	NA

Table 9. TOTAL PHOSPHORUS TROPHIC STATE INDICES RANKING

Below are the rankings of the assessment lakes by Carlson's TSI for total phosphorus. The lakes are ranked from hyper-eutrophic to oligotrophic.

1	Cottonwood Lake, (Sully)	107.81	56	Hendricks, Lake	79.62
2	Cresbard Lake	105.96	57	Madison, Lake	79.52
3	Silver Lake	103.67	58	Alvin, Lake	79.46
4	Wilmarth Lake	103.20	59	Swan Lake	78.91
5	Pocasse, Lake	102.18	60	Traverse, Lake	78.62
6	Louise, Lake	101.56	61	Lakota, Lake	78.56
7	Rosette Lake	101.19	62	Hayes Lake	78.10
8	Academy Lake	101.02	63	Bierman Gravel Pit	77.19
9	Sully Lake	99.37	64	Loyalton Dam	77.10
10	Whitewood Lake	99.16	65	Poinsett, Lake	77.02
11	Rosehill Lake	98.58	66	Fate Dam	77.00
12	Corsica Lake	98.52	67	Murdo Dam	77.00
13	Faulkton, Lake	98.29	68	Fish Lake	76.84
14	Redfield Lake	98.14	69	White Lake Dam	76.79
15	Mina Lake	97.48	70	Stockade Lake	76.33
16	Geddes Lake	96.22	71	Brant Lake	76.12
17	New Wall Lake	95.45	72	Blue Dog Lake	74.86
18	Roosevelt Lake	94.87	73	Covell Lake	74.04
19	Kampeska, Lake	94.67	74	Clear Lake (Duel)	73.66
20	Carthage, Lake	94.66	75	Big Stone Lake	73.10
21	Cottonwood Lake (Spink)	94.29	76	Center Lake	73.02
22	Burke Lake	92.82	77	Alice, Lake	71.96
23	Elm Lake	92.78	78	Minnewasta Lake	71.48
24	Thompson, Lake	92.40	79	Hanson, Lake	70.77
25	Mitchell, Lake	92.12	80	Bullhead Lake	70.48
26	Rahn Dam	91.92	81	Sylvan Lake	70.15
27	Amsden Dam	90.77	82	Pelican Lake	69.54
28	Preston, Lake	90.48	83	Pierpont Lake	68.99
29	Byron, Lake	90.22	84	Twin Lakes	67.68
30	Ravine Lake	89.97	85	Shadehill Reservoir	66.77
31	East Vermillion Lake	89.87	86	Newell Lake	66.61
32	Beaver Lake	89.86	87	South Buffalo Lake	65.85
33	Andes, Lake	88.56	88	Sully Dam	65.85
34	Hiddenwood, Lake	87.93	89	Punished Woman's Lake	65.44
35	Herman, Lake	87.55	90	Roy Lake	65.44
36	Norden, Lake	86.75	91	Nine Mile Lake	65.39
37	Jones Lake	85.85	92	Legion Lake	63.92
38	Coal Springs Dam	85.08	93	Freeman Lake	62.73
39	Waggoner Lake	84.99	94	Sheridan Lake	62.15
40	Marindahl Lake	84.52	95	Newell City Pond	62.09
41	Platte, Lake	84.30	96	Brakke Lake	60.80
42	Henry, Lake	83.91	97	Iron Creek Lake	60.30
43	Albert, Lake	83.81	98	Clear Lake (Marshall)	58.36
44	School Lake	83.63	99	Yankton, Lake	58.24
45	Flat Creek Dam	83.04	100	South Red Iron Lake	57.00
46	Isabell, Lake	82.61	101	Orman Dam	52.14
47	Campbell, Lake (Brookings)	81.96	102	Pickerel Lake	51.66
48	Richmond Lake	81.51	103	Angostura Reservoir	49.08
49	Horsethief Lake	81.31	104	Canyon Lake	49.07
50	Dewberry Lake	81.29	105	Cochrane, Lake	48.90
51	East Oakwood Lake	81.17	106	Deerfield Lake	46.79
52	Bismark Lake	80.66	107	Enemy Swim Lake	46.69
53	McCook Lake	80.12	108	Cold Brook Reservoir	38.07
54	Wall Lake	79.89	109	Pactola Reservoir	35.51
55	Dante Lake	79.85	110	Campbell, Lake (Campbell)	NA

Table 10. CHLOROPHYLL "a" TROPHIC STATE INDICES RANKING (corrected)

Below are the rankings of the assessment lakes by Carlson's TSI for Chlorophyll "a". The lakes are ranked from hyper-eutrophic to oligotrophic.

1	Albert, Lake	80.86	56	Roosevelt Lake	55.00
2	Burke Lake	80.65	57	Cresbard Lake	55.00
3	East Oakwood Lake	78.59	58	Waggoner Lake	54.86
4	Thompson, Lake	76.97	59	Jones Lake	54.34
5	Poinsett, Lake	75.80	60	Isabell, Lake	53.21
6	Cottonwood Lake (Spink)	75.53	61	Amsden Dam	52.53
7	Whitewood Lake	73.61	62	Iron Creek Lake	52.53
8	Clear Lake (Duel)	73.19	63	Sheridan Lake	52.48
9	Madison, Lake	73.10	64	Norden, Lake	52.18
10	Andes, Lake	72.82	65	Bullhead Lake	51.76
11	Henry, Lake	72.20	66	Big Stone Lake	51.55
12	Fish Lake	71.84	67	Horsethief Lake	51.02
13	Pierpont Lake	69.06	68	Clear Lake (Marshall)	50.33
14	Platte, Lake	68.32	69	Lakota, Lake	50.16
15	Beaver Lake	67.89	70	Brant Lake	49.82
16	Rahn Dam	67.70	71	Elm Lake	49.23
17	Alvin, Lake	67.44	72	Twin Lakes	48.55
18	Alice, Lake	67.44	73	Rosette Lake	48.20
19	Flat Creek Dam	67.44	74	Rosehill Lake	48.20
20	Pelican Lake	67.29	75	Newell Lake	47.50
21	Ravine Lake	66.97	76	Richmond Lake	47.09
22	Hiddenwood, Lake	66.97	77	Shadehill Reservoir	47.08
23	Mina Lake	66.64	78	Pickerel Lake	46.65
24	Faulkton, Lake	66.47	79	Cold Brook Reservoir	46.63
25	Traverse, Lake	66.47	80	East Vermillion Lake	46.35
26	Center Lake	65.95	81	Marindahl Lake	44.87
27	Nine Mile Lake	65.21	82	Enemy Swim Lake	44.12
28	Campbell, Lake (Campbell)	65.02	83	Newell City Pond	43.38
29	White Lake Dam	65.02	84	Yankton, Lake	43.05
30	Sylvan Lake	64.97	85	Fate Dam	42.43
31	Loyalton Dam	63.76	86	Coal Springs Dam	40.24
32	Bismark Lake	63.76	87	Angostura Reservoir	38.52
33	Cochrane, Lake	62.90	88	Pactola Reservoir	35.21
34	Cottonwood Lake, (Sully)	62.83	89	Orman Dam	34.83
35	Carthage, Lake	62.83	90	Deerfield Lake	33.80
36	Corsica Lake	62.66	91	Academy Lake	NA
37	South Red Iron Lake	62.06	92	Bierman Gravel Pit	NA
38	Herman, Lake	61.80	93	Byron, Lake	NA
39	Canyon Lake	61.23	94	Campbell, Lake (Brookings)	NA
40	Geddes Lake	60.79	95	Covell Lake	NA
41	Minnewasta Lake	60.65	96	Dante Lake	NA
42	South Buffalo Lake	60.64	97	Dewberry Lake	NA
43	Hanson, Lake	60.33	98	Freeman Lake	NA
44	Blue Dog Lake	60.01	99	Hendricks, Lake	NA
45	Roy Lake	59.65	100	Kampeska, Lake	NA
46	Louise, Lake	59.33	101	McCook Lake	NA
47	Brakke Lake	58.60	102	Murdo Dam	NA
48	Mitchell, Lake	57.68	103	Preston, Lake	NA
49	Wilmarth Lake	57.39	104	Punished Woman's Lake	NA
50	New Wall Lake	57.08	105	Redfield Lake	NA
51	Pocasse, Lake	56.96	106	School Lake	NA
52	Silver Lake	56.82	107	Sully Dam	NA
53	Legion Lake	56.03	108	Sully Lake	NA
54	Hayes Lake	55.53	109	Swan Lake	NA
55	Stockade Lake	55.42	110	Wall Lake	NA

AQUATIC PLANT SURVEY

In the summer of 1993 an aquatic plant survey was conducted at Pelican Lake. Thirty different samples were obtained from representative locations in the lake. Due to the methods employed a quantitative analysis was not possible, although algal identification was completed for all samples. The results of the aquatic plant survey are shown in Table 11 below. Samples were analyzed in the biology lab at Augustana College, Sioux Falls South Dakota.

Table 11. Pelican Lake Aquatic Plant Survey, September, 1993

Shoreline and Emergent Vegetation
Cattail and Bullrush

Floating Leaved and Submergent Plant Species
None Observed

Algal Species
Aphanazomenon flos-aquae
Anabaena
Cryptomonas
Fragilaria
Oocystis
Other Blue-Green
Other Green (few)

FISHERIES

Pelican Lake is managed as a meandered lake with a warm water marginal fishery by the SD Game, Fish and Parks Department. Primary species include northern pike, yellow perch, and walleye. The Pelican Lake fisheries also support several secondary species which include: common carp, white sucker, black bullhead, bigmouth buffalo, and black crappie. These primary and secondary species provide excellent recreational opportunities for residents and non-residents alike.

Biological Data

Methods:

Pelican lake was surveyed on July 13-15, 1993 (SD Game, Fish and Parks, 1993). A total of six 150' experimental gill nets and eighteen 3/4" frame nets were used. Shoreline seining was conducted on August 18, 1993. Lengths and weights were taken from all fish samples. Scales were taken from the walleye collected. The DisBcal program was used to analyze age and growth data and the FishCalc program was used to calculate proportional stock density (PSD) and condition (WR) information.

Results and Discussion:

In 1993 eleven species were observed during test netting. Two species, small mouth bass and shorthead redhorse, were observed for the first time, probably entering from the Big Sioux River.

Pelican Lake has in the past provided thousands of hours of angling opportunity for yellow perch. In 1987, the yellow perch gill net CPUE (catch-per-unit-effort) was 529.5 (300' nets). That winter nearly 300 ice shanties were observed on the lake, with a lot of yellow perch being caught. During the summer of 1988 and again after ice out in 1989 there was some evidence of fish loss. Both were considered light, but in 1989 the yellow perch gill net CPUE had dropped significantly to 18.4. In 1991 it dropped further to 2.0. After a slight increase to 6.3 in 1992, the gill net CPUE decreased again to 4.8 in 1993 (Table 12). Although adequate brood stock has been present, natural reproduction and recruitment has been nil. Recent stocking efforts do not appear to have made any significant contribution (Appendix D). If natural reproduction is poor again in 1994, attempts should be made to stock yellow perch from natural pond production at 100 per acre. The yellow perch ranged in length from 11-35 cm. and had a PSD of 26.

The walleye gill net CPUE was 4.3 (Table 12), changing very little the last three years. Lengths ranged from 22 to 60 cm (8 to 24 inches). Five year classes were represented with the majority being age 2 and 1. The growth rate slowed due to an unseasonably cold summer, but was still one of the best in the region with an average length of 36.3 cm (14.5 inches) being attained at age 2.

Table 12. Total catch of 6/150 ft. experimental gill nets, July 13-15, 1993.

SPECIES	%COMP	N	CPUE 80% C.I	2 YEAR MEAN CPUE	PSD	WR
YEP	30.2	29	4.83 +-1.54	5.58	26	128
NOP	6.25	6	1.00 +-0.54	1.67	-	-
WAE	27.08	26	4.33 +-4.06	4.08	74	107
SHR	3.13	3	0.50 +-0.50	0.25	-	-
WHS	19.79	19	3.17 +-1.68	3.59	-	-
COC	13.54	13	2.17 +-1.29	2.42	-	-

The northern pike gill net CPUE dropped from 2.3 in 1992 to 1.0 in 1993. They ranged in length from 55 to 80 cm (22 - 32 inches). No young of the year were observed.

In 1989 the black bullhead frame net CPUE increased to 127.5, and bullheads were soon blamed for the problems with the yellow perch population. Commercial fishing efforts were initiated. By 1992 the CPUE had dropped to 4.1. In 1993, no black bullheads were sampled in the gill nets and the frame nets' CPUE was 0.9. They ranged in length from 14 to 36 cm (5.6 to 14.4 inches).

Other species represented in the survey included white sucker, carp, bigmouth buffalo, black crappie, orange-spotted sunfish, and white bass.

No young of the year game fish were found during shoreline seining efforts.

Recommendations (SD Game Fish and Parks, 1993):

1. Continue to manage primarily for northern pike, walleye, and yellow perch.

2. If yellow perch natural reproduction is poor again in 1994, attempt to stock a minimum of 100 fingerlings per acre from natural pond production. If the stocking is made, evaluate its contribution to the yellow perch fishery.

3. Commercial fishing efforts for carp and buffalo should be maintained.

4. Re-survey in 1994.

SEDIMENT SURVEY

Preliminary sediment testing of Pelican Lake was conducted as a cooperative effort between the Department of Environment and Natural Resources and the Pelican Lake Water Project District on March 27, 1993. A total of 52 test holes were drilled through the ice, running from east to west, obtain measurements (Table 13). The spacing between the drilled holes was approximately one tenth of a mile. Water and sediment depths were recorded at each hole.

Table 13. Sediment Sampling Results, March 27, 1993.

Hole Number	Water Depth (feet)	Sediment Depth (feet)
1	3.0	3.0
2	5.5	2.0
3	6.0	6.0
4	6.5	9.0
5	7.0	3.5
6	7.2	6.7
7	7.0	3.0
8	7.2	8.0
9	7.2	0.0
10	7.2	9.0
11	7.2	8.7
12	7.2	5.7
13	7.2	5.7
14	7.7	9.5
15	7.7	7.2
16	7.7	5.2
17	7.7	6.5
18	8.2	6.7
19	8.0	7.5
20	8.0	7.5
21	8.2	7.2
22	8.0	7.5
23	8.2	6.7
24	8.0	6.0
25	8.2	5.7
26	8.0	7.5
27	8.2	7.2
28	8.2	7.5
29	8.2	7.7
30	8.2	7.5
31	8.2	7.2
32	8.2	7.2
33	8.2	4.0
34	8.2	4.5
35	8.2	7.7
36	8.5	7.0
37	8.2	6.7
38	8.5	7.0
39	8.2	7.5
40	8.2	6.0
41	8.0	8.0
42	8.0	7.2
43	8.0	7.0
44	8.0	6.0
45	8.2	5.7
46	8.0	6.0
47	8.0	5.0
48	7.7	6.0
49	7.7	7.2
50	7.7	5.2
51	7.2	7.0
52	6.0	2.5

Based on an average sediment depth of 6.5 feet in the 52 holes, the total measured sediment volume was calculated to be in excess of 4 million cubic yards. Because of the limitations of the measuring equipment, the actual total sediment volume was assumed to be much greater than the volume that was measured. The majority of the lake contained measurable sediment deposits, many of them exceeding 7 feet. Based on these observations, it appears that Pelican Lake was originally a much deeper lake.

Seismic Survey

A much more thorough survey to assess the amount and distribution of sediment in Pelican Lake was conducted during June 7-22, 1994, by the U.S. Geological Survey with assistance from the South Dakota Department of Environment and Natural Resources and the Pelican Lake Water Project District. The primary purpose of the survey was to determine the thickness and volume of fine-grained, silty, lake sediment. A secondary objective of the study was to determine the depth and volume of water in Pelican Lake. Other objectives were to produce an elevation/capacity/area table for Pelican Lake, and to produce a contour map and cross-sectional profiles to show the areal distribution of sediment in the lake. Results of the sediment survey that are presented in this report are preliminary and may be subject to revision.

A high-frequency, continuous seismic-reflection system was used to estimate thickness of sediment, and a global-positioning system was used to monitor horizontal position while traversing 27 northwest-southeast transepts (spaced 1000 feet apart) and one diagonal transect of the lake. No seismic record was obtained in the eastern part of the lake due to an interference (probably caused by the presence of gas produced by microbial decomposition of organic material in the sediment) that prevented penetration of the seismic signal. The volume of sediment in the eastern part of Pelican Lake was estimated using an average sediment thickness determined for the western part of the lake from seismic record. Preliminary results of the sediment survey indicate the total volume of fine-grained silty sediment in the lake was about 36 million cubic yards. The maximum sediment thickness was about 23 feet and the mean sediment thickness was about 8 feet in the western part of the lake. Figure 30 shows contour lines of fine-grained sediment thickness in the western part of Pelican Lake. Figure 31 shows the location of the interface between coarser sand and gravel and fine-grained silty sediment in Pelican Lake.

Water depth was measured using a standard fathometer. The mean water surface elevation of Pelican Lake was about 1710.6 feet above sea level during the survey. The volume of water in Pelican Lake was calculated to be 18,150 acre feet. The maximum water depth was 8.8 feet and the average water depth was 6.5 feet. Figure 32 shows water-depth contour lines and Table 14 presents elevation /capacity/area information for Pelican Lake.

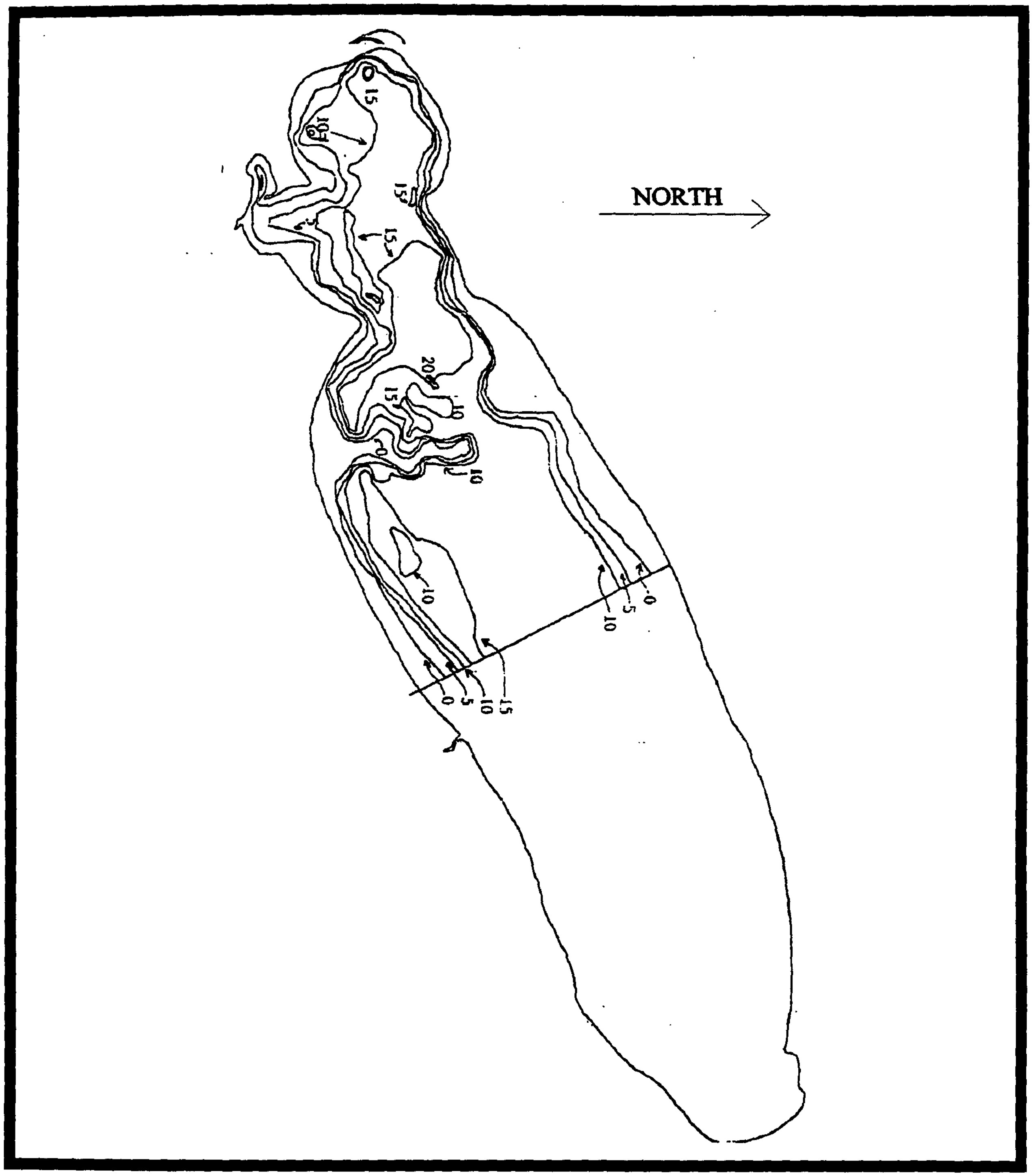


Figure 30. Contour Lines of Fine-Grained Sediment Thickness for the Western Section of Pelican Lake

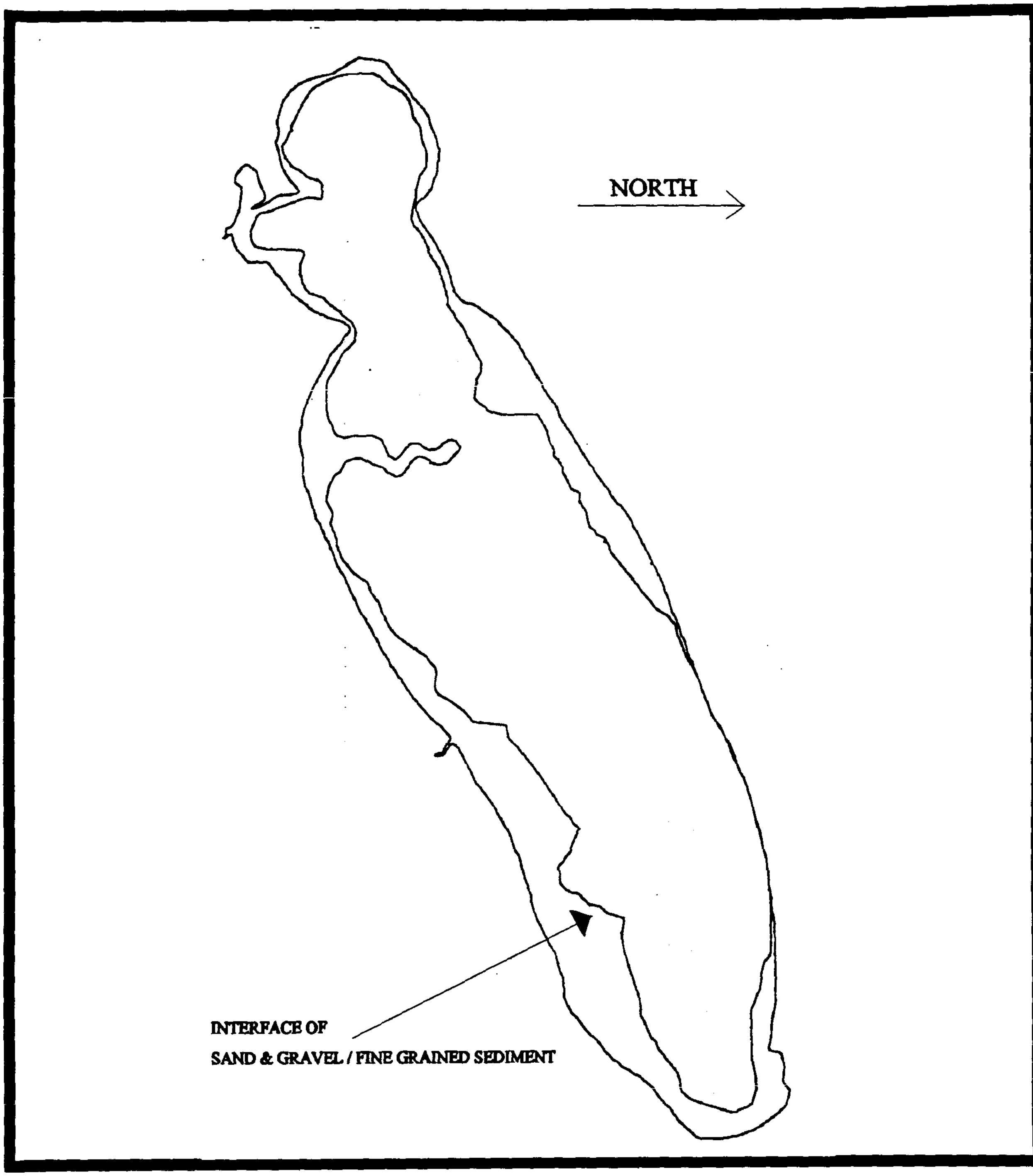


Figure 31. Interface between Coarser Sand and Gravel and the Fine-Grained Sediment

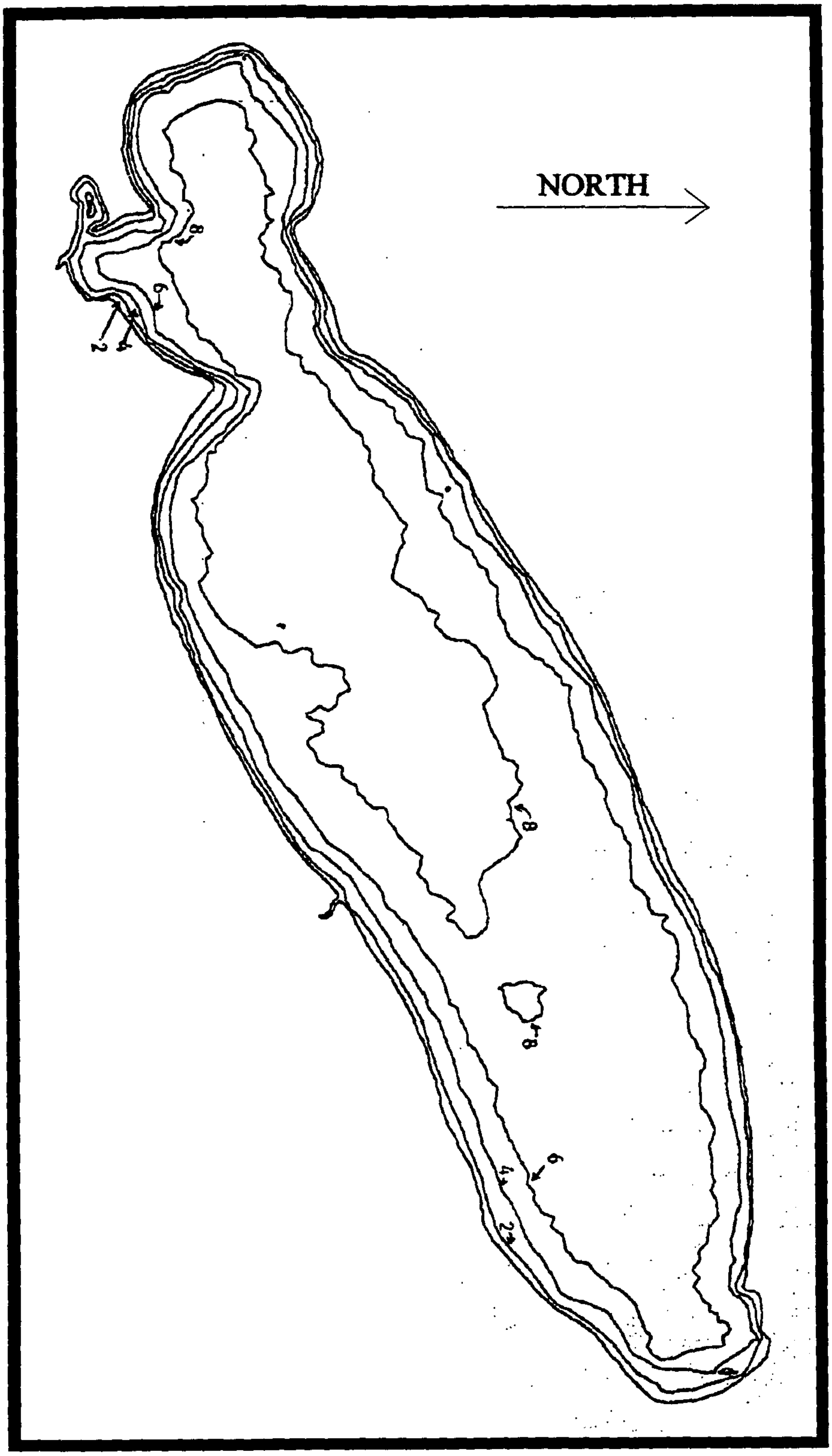


Figure 32. Contour Lines of Water Depth for Pelican Lake

Table 14. Elevation/ Capacity/ Area information for Pelican Lake

Elevation in Feet Above Sea Level	Capacity in acre feet	Area, in Acres
1,710.6	18,152	2,809
1,710	18,110	2,767
1,709	18,039	2,696
1,708	17,800	2,601
1,707	17,448	2,489
1,706	16,678	2,315
1,705	15,630	2,100
1,704	12,655	1,649
1,703	8,397	1,041
1,702	1,674	199

ELUTRIATE and SEDIMENT SAMPLING

Sediment and water samples were collected from Pelican Lake on September 12, 1991. The samples were sent to the U. S. Army Corps of Engineers Laboratory at Omaha, Nebraska, for analysis. The analyses were conducted on the sediment sample, the lake water sample (receiving water), and the water sample resulting from mixing of the sediment and lake water (elutriate water). The purpose of running these tests was to determine if removal of sediment from the lake might cause detrimental effects in the receiving water or in areas of sediment disposal. All of the samples were analyzed for metals, pesticides, and other toxic substances. In addition, the receiving water and elutriate water were tested for hardness, nutrients, chemical oxygen demand (COD), total cyanide, and oil and grease. The sample results are shown in Table 15.

Although the sediment samples were not analyzed for nutrients, some assumptions can be made about nutrients in the sediment by comparing concentrations in the lake water (receiving water) with concentrations in the elutriate water (lake water mixed with sediment). The sediment appears to release ammonia nitrogen from bacteria decomposing organic material, and total Kjeldahl nitrogen which could be organic material not yet decomposed. No definite assumptions can be made about nitrate-nitrite nitrogen as there are only very small differences between the receiving water and the elutriate water. The total phosphorus concentration is slightly higher in the elutriate water than in the receiving water. This would tend to indicate that only a small amount of phosphorus would be released into the lake during a dredging operation.

The main purpose of analyzing the sediment, lake water, and elutriate water was to determine concentrations of metals, pesticides, and other toxic substances. The results showed that the sediment, lake water, and elutriate water did not appear to contain high concentrations of contaminated material. The results are similar to results for other South Dakota lakes, and indicate that adverse effects from any potential dredging projects should be minimal.

Table 15. Pelican Lake Sediment and Elutriate Sample Data

DEPARTMENT OF THE ARMY
Missouri River Division, Corps of Engineers
Division Laboratory
Omaha, Nebraska

Project: Section 22 PAS Project for South Dakota
Date Sample Taken: 12 Sep 91
Date Sample Received: 17 Sep 91
Sample Description: Water and Sediment
Time Sample Taken: 1500

Customer Sample Id: Pelican Lake
Lab Sample No: 910919-W001, W002, & W003
Sample Container: 1-1 gal wide mouth glass (sed)
3-1 gal amber glass (water)

Analysis	Sediment Result	Units	Receiving Water Result	Units	Elutriate Water Result	Units
Ca and Mg Hardness			290	mg/L	311	mg/L
Ammonia Nitrogen			0.17	mg/L	4.1	mg/L
Chemical Oxygen Demand			34	mg/L	430	mg/L
Total Cyanide			<0.02	mg/L	<0.02	mg/L
Nitrate-Nitrite Nitrogen			<0.01	mg/L	0.02	mg/L
Total Phosphorus			0.03	mg/L	0.05	mg/L
Total Kjeldahl Nitrogen			1.8	mg/L	6.6	mg/L
Oil and Grease			<5	mg/L	<5	mg/L
Antimony	<0.5	mg/kg	<1	µg/L	2	µg/L
Arsenic	5.6	mg/kg	6	µg/L	7	µg/L
Barium	260	mg/kg	130	µg/L	160	µg/L
Beryllium	<0.1	mg/kg	<1.0	µg/L	<1.0	µg/L
Cadmium	<0.5	mg/kg	<0.1	µg/L	<0.1	µg/L
Chromium	24	mg/kg	<1	µg/L	<1	µg/L
Copper	1.7	mg/kg	<10	µg/L	<10	µg/L
Iron	19000	mg/kg	620	µg/L	1400	µg/L
Lead	11	mg/kg	<1.0	µg/L	<1.0	µg/L
Magnesium	14000	mg/kg	54	mg/L	53	mg/L
Manganese	1800	mg/kg	<5	µg/L	1000	µg/L
Mercury	<0.10	mg/kg	<0.2	µg/L	<0.2	µg/L
Selenium	0.39	mg/kg	<1.0	µg/L	1.0	µg/L
Zinc	69	mg/kg	<10	µg/L	<10	µg/L
Nickel	22	mg/kg	10	µg/L	6	µg/L
Aluminum	17000	mg/kg	<50	µg/L	<50	µg/L
Calcium	120000	mg/kg	27	mg/L	37	mg/L
Sodium	170	mg/kg	29	mg/L	29	mg/L
Potassium	2700	mg/kg	13	mg/L	15	mg/L
Silver	1	mg/kg	<10	µg/L	<10	µg/L
Simazine (Princep)	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
Metribuzin (Lexone)	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
Atrazine (Aatrex)	<100	µg/kg	0.10	µg/L	<0.10	µg/L
Aldrin	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
alpha-BHC	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
beta-BHC	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
gamma-BHC (Lindane)	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Mirex	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Chlordane	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
P'P"DDD	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
P'P"DDE	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
P'P"DDT	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Dieldrin	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Endosulfan I	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Propachlor (Ramrod)	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
Metolachlor (Dual)	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
Alachlor (Lasso)	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
Diazinon	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
Endrin	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Heptachlor	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Heptachlor epoxide	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Methoxychlor	<10	µg/kg	<0.01	µg/L	<0.01	µg/L
Toxaphene	<500	µg/kg	<0.50	µg/L	<0.50	µg/L
PCB-1016	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
PCB-1221	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
PCB-1232	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
PCB-1242	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
PCB-1248	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
PCB-1254	<100	µg/kg	<0.10	µg/L	<0.10	µg/L
PCB-1260	<100	µg/kg	<0.10	µg/L	<0.10	µg/L

SURFACE WATER HYDROLOGY--TRIBUTARIES

This section will include a site by site analysis of water flow, duration, and effect of the tributary streams in relation to hydrologic loading to Pelican Lake. Refer to Figure 4 for locations of the tributary monitoring sites.

Site PL-1 (State Park)

This tributary monitoring site was situated in a shallow basin that leads to the southwest end of Pelican Lake. The area draining to this site consists of hilly grazing and rowcrop land. The stage recorder was placed in an area of channelized flow. The drainage basin had a point of constriction, a twelve-foot culvert under a railroad grade, in a wetland approximately 1/2 mile upstream.

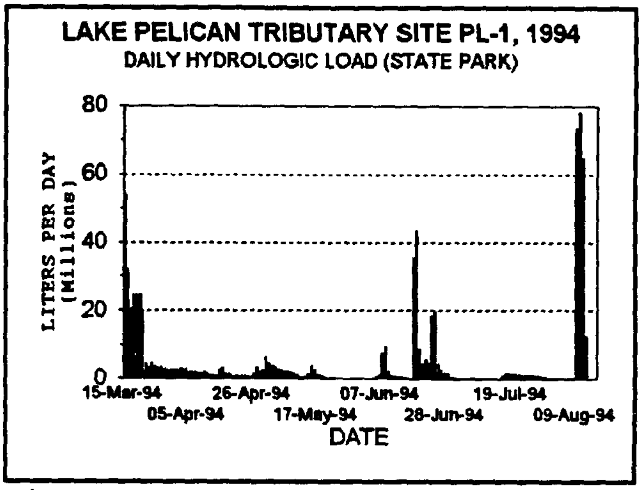


Figure 33. PL-1 Hydrologic Load

The major flow of water at this monitoring site occurred during snowmelt runoff (Figure 33). Minor intermittent flows were recorded during the remainder of the study period, with brief periods of no flow. This site was influenced by flows from storm events over a large portion of the study period.

After snowmelt in the spring, five storm events caused the greatest flows of water at this site. These flows caused a sharp increase in stage with a short duration, followed by lower steady flows for extended periods after the initial flush. This was in contrast to Sites PL-2 and PL-3 which exhibited short bursts of water, followed by extended periods of no flow (Figure 34). Overall during the study period, Site PL-1 had steady flows, with only temporary periods of no flow.

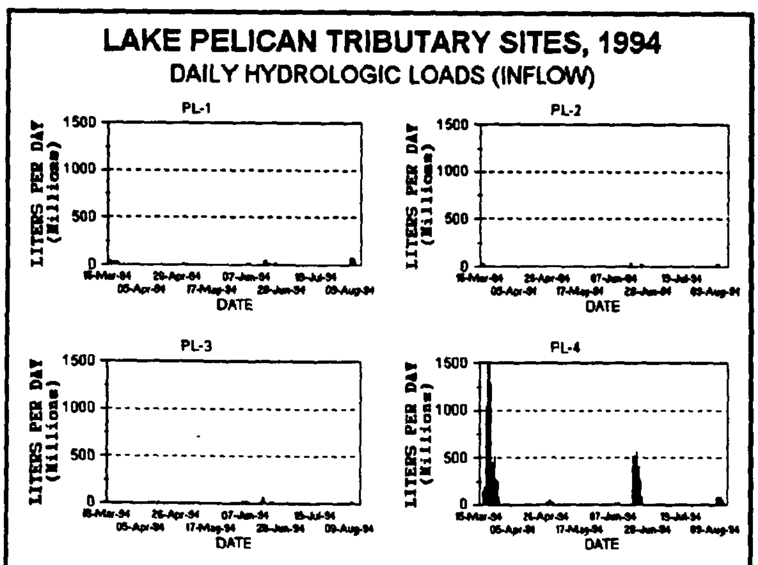


Figure 34. Hydrologic Loads (Inflow)

Site PL-2 (Air Haven)

Site PL-2 exhibited only intermittent flows. The flow which occurred during the spring snowmelt equalled the combined storm event flows for the remainder of the year (Figure 35). The intensities of storm events which were required to cause flow at this site were greater than those at Site PL-1 and PL-3 . Site PL-2 only flowed following three storm events, in comparison to the five and six storm events that caused flow at Sites PL-1 and PL-3, respectively (Figure 34). The flows at this site exhibited rapid peaks followed by rapid declines to dry channel conditions.

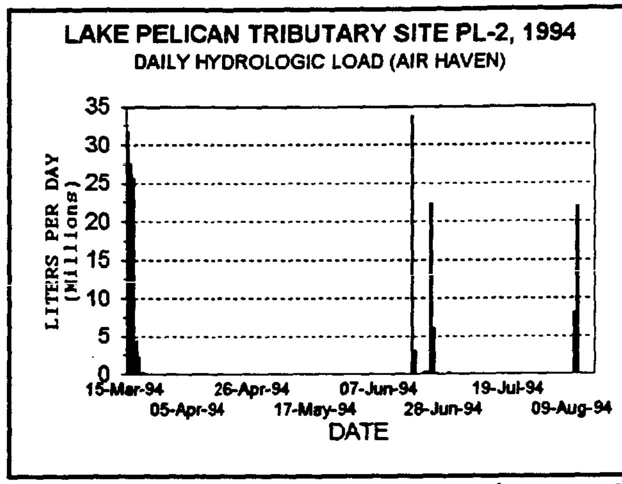


Figure 35. PL-2 Hydrologic Load

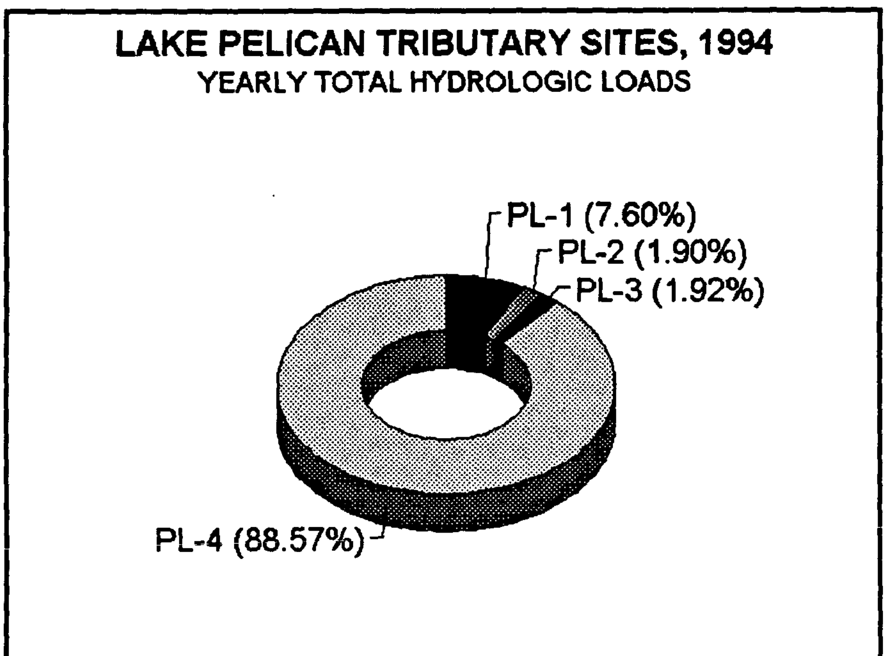


Figure 36. Yearly Total Hydrologic Loads

There were only twenty days with measurable flows at Site PL-2 during the study period. The remainder of the time the channel was dry. The flows at this site represented only 1.90% of the total hydrologic flow into the Pelican Lake system (Figure 36). The volumetric loading from this inflow site, compared to the volumetric loadings from the other inflow sites, represents only a small portion of the total volumetric loading to Pelican Lake.

Site PL-3 (Foley Road)

The flow pattern at this tributary monitoring site was an exception to the flow patterns observed at the other immediate watershed sites PL-1 and PL-2 (Figure 34). Although snowmelt occurred on March 15, 1994, in this subwatershed, the culverts under the bridge at Site PL-3 remained plugged with snow and ice. This caused the water that would have otherwise gone into Pelican Lake to be diverted through an adjacent field and into the Big Sioux River downstream from the lake. Flow monitoring at this site began in mid-April after the snow and ice pack in the culverts had melted (Figure 37). All of the flows monitored at this site represent storm events. This influenced the mean time for inflow of chemical parameters for the entire immediate watershed area.

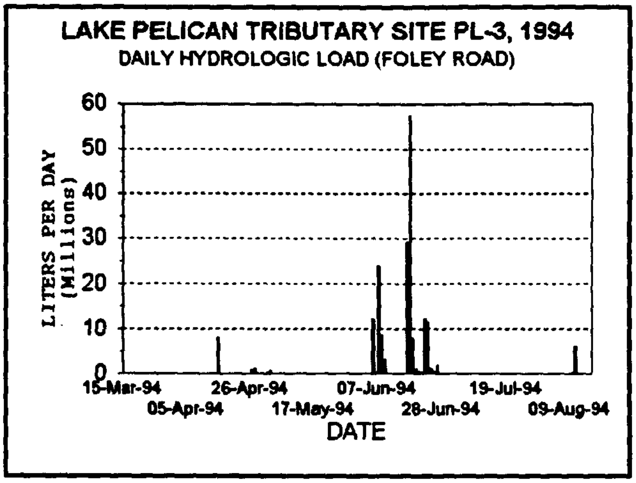


Figure 37. PL-3 Hydrologic Load

The Foley Road site exhibited rapid peaks in flow, with extended periods of high flow. This may have been caused by sediment retention structures already in place in this subwatershed. The flows at this site represented only 1.92% of the total hydrologic flow into the Pelican Lake system during the study period (Figure 36). When compared to the other immediate watershed sites, Site PL-3 ranks second after PL-1, but ahead of Site PL-2, for total hydrologic input to Pelican Lake.

Site PL-4/5

Flow for the Big Sioux River inlet/outlet channel (site PL-4/PL-5) was calculated based on stages at a site located in the Big Sioux River diversion to Pelican Lake. Additional data used to calculate flow and direction of flow at this site included stage data at the Big Sioux River spillway near U. S. Highway 212, U.S.G.S. data from gaging stations on the Big Sioux River upstream of Pelican Lake (near Watertown, Florence, and Lake Kampeska inlet/outlet), and climatological data obtained from the Watertown Regional Airport meteorological station.

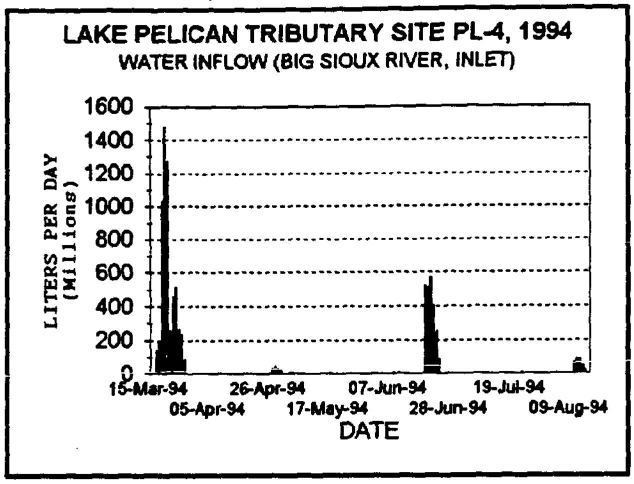


Figure 38. PL-4 Water Inflow

The Big Sioux River (PL-4) represented the major hydrologic contribution to Pelican Lake during the study period (Figure 36).

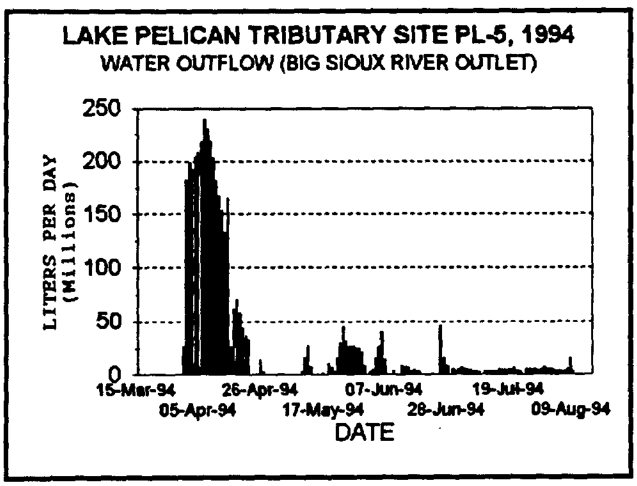


Figure 39. PL-5 Water Outflow

The largest inflow of water to the lake occurred during snowmelt runoff in early spring (Figure 38).The inflow from the Big Sioux River peaked rapidly, followed by an extended period of high water, until the river level decreased and the lake level equalized with the river. After equalization, the flow direction changed and water flowed out of the lake for extended periods of time except for minor inflows following rainstorm events in the Big Sioux River watershed. For the most part, water flowed out of Pelican Lake (PL-5) at a reduced, but steady rate during the study period (Figure 39).

Ground Water Connection

During the study period, the Pelican Lake hydrologic system showed that greater amounts of water entered the lake at Site PL-4 than flowed out at Site PL-5, after accounting for evaporation and ground water withdrawal from wells in the vicinity of the lake. This indicates that a significant amount of water was lost through ground water outflow. Consequently, there appears to be a major ground water connection between the lake and the Big Sioux aquifer.

TRIBUTARY MONITORING RESULTS

FECAL COLIFORM BACTERIA

Fecal coliform bacteria found in water samples can indicate fecal contamination and thus potential human health hazards. Fecal coliform bacteria are bacteria which live in the digestive tract of warm-blooded animals. These bacteria are considered to be indicators of pollution from sewage or livestock manure. Fecal coliform bacteria are not found in the digestive tracts of cold-blooded animals such as fish or amphibians.

The mean fecal coliform bacteria counts for Sites PL-1, PL-3, PL-4, and PL-5 were well below the state mean standard of 10,000 colonies per 100 mL (Figure 40).

Site PL-2, on the other hand, exhibited different characteristics, due to livestock feeding areas. The mean fecal coliform bacteria result at this site was 47,958 colonies per 100 mL (Figure 40). This indicated a possible increase in other potentially pathogenic organisms in the water entering Pelican Lake. In spite of the increased level of bacteria that entered Pelican Lake at this site, the in-lake data did not show that it had a profound effect on total in-lake bacteria counts. The flow of water at this site appeared to be a source of potentially harmful organisms, but based on the current data available, it seemed to be a localized problem.

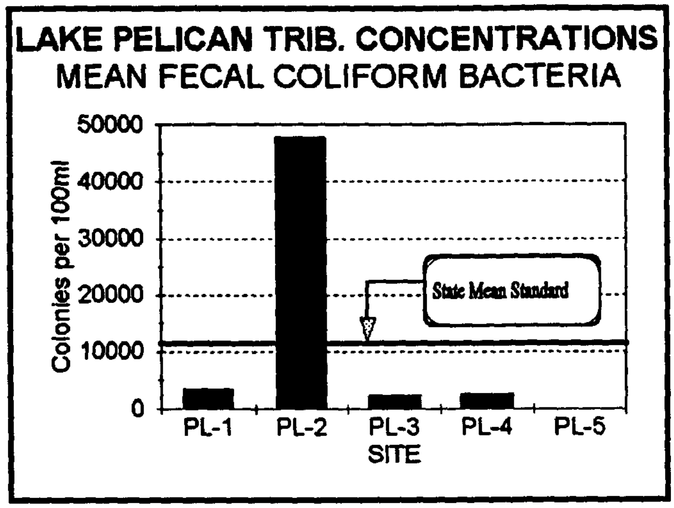


Figure 40. Mean Fecal Coliform Bacteria

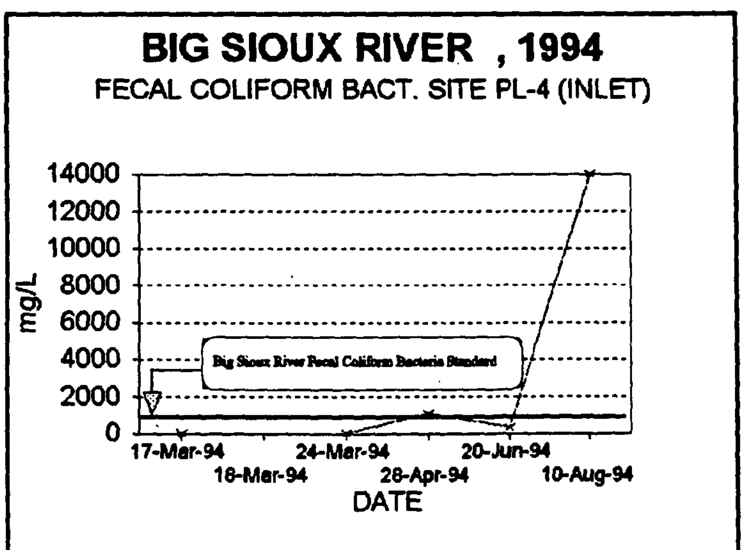


Figure 41. PL-4 Fecal Coliform

The fecal coliform bacteria results at Site PL-4 (Big Sioux River inlet) exceeded the state standard of 1,000 colonies per 100 mL on two occasions following storm events in April and August, 1994 (Figure 41). Other than these two occasions, the results at this site met state water quality standards.

DISSOLVED OXYGEN

The dissolved oxygen content of a lake results from the activities of growth and decomposition in the lake system. The air to water interface, and the distribution of oxygen by wind driven mixing, are also factors in the dissolved oxygen level. Oxygen levels less than 3.0 mg/L are stressful to aquatic invertebrates and most other aquatic life.

The mean dissolved oxygen (D. O.) results for the tributary stream sites were almost all above the state water quality standards except for Site PL-2 (Air Haven) (Figure 42). No large aquatic organisms were observed at this site during the sampling period. In comparison, aquatic organisms such as crayfish and minnows were routinely observed at Sites PL-1, PL-3, and PL-4/5.

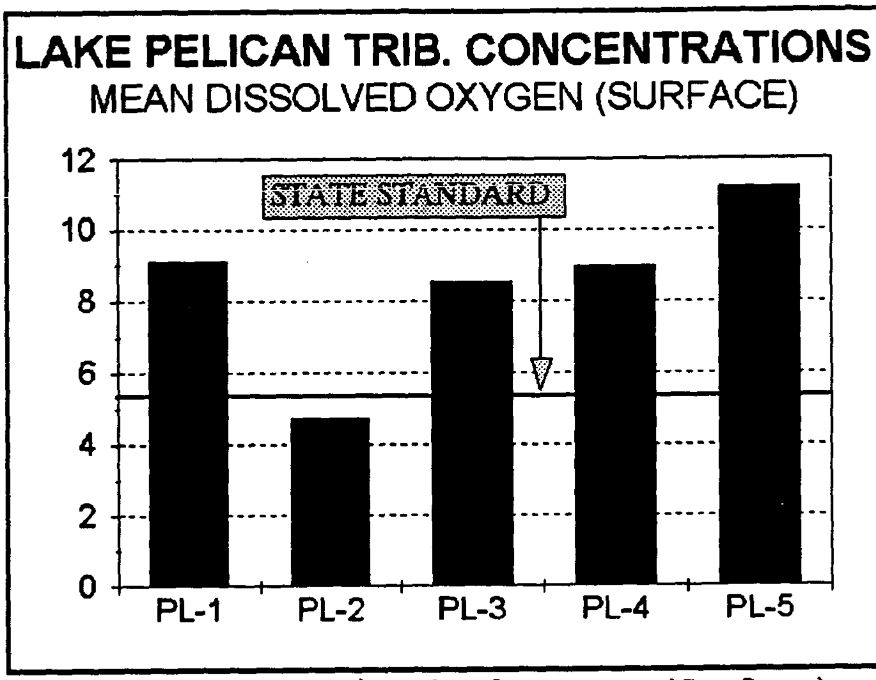


Figure 42. Mean Dissolved Oxygen (Surface)

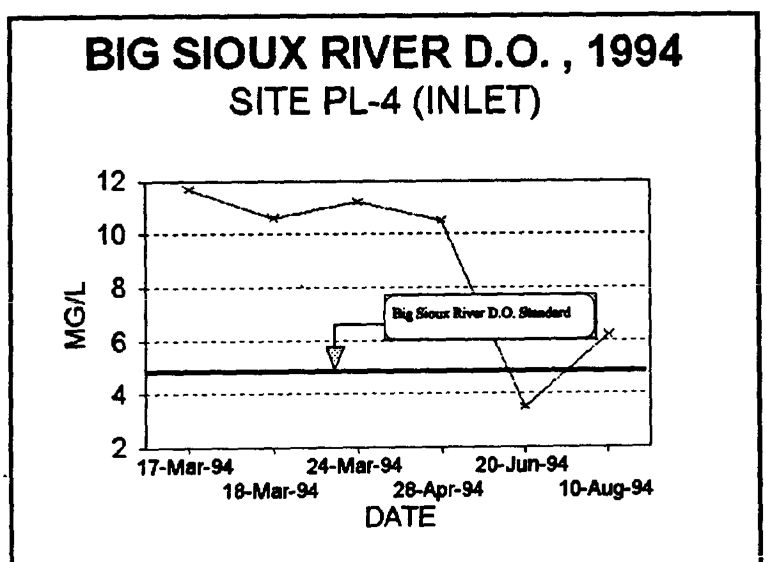


Figure 43. PL-4 (Inlet) Dissolved Oxygen

Site PL-4 (Big Sioux River inlet) had above standard (5.0 mg/L) levels on all but one occasion (Figure 43). On the June 20, 1994, sample date the D.O. at this site fell to 3.5 mg/L following a rainstorm event. This did not appear to have a substantial effect on overall lake dissolved oxygen levels.

pH

Field and laboratory pH is a measure of the hydrogen ion activity in water which directly affects the toxicity (solubility) of heavy metals in water, as well as many other factors. The pH scale is a number range between 1 and 14, with 7 being neutral. Any value less than 7 is considered acidic, and any value greater than 7 is considered basic, or alkaline. The pH range for most natural lakes is between 6 and 9. Deviation from a neutral pH of 7 is a result of the decomposition of salts as they react with water. Gases such as carbon dioxide, hydrogen sulfide, and ammonia have a significant effect on pH. The pH level of a lake is also directly related to the geography of the surrounding area.

The mean field pH results at all tributary stream sites were within the state standard range of 6.5 to 9.0. Site PL-2 (Air Haven) had the lowest average pH results, and Site PL-5 (Big Sioux River outlet) exhibited the highest mean pH results (Figure 44). These results indicated that water flowing out of Pelican Lake had a greater buffering capacity than water which entered the lake from surface drainage. This increase in buffering capacity indicates a possible strong ground water connection to Pelican Lake.

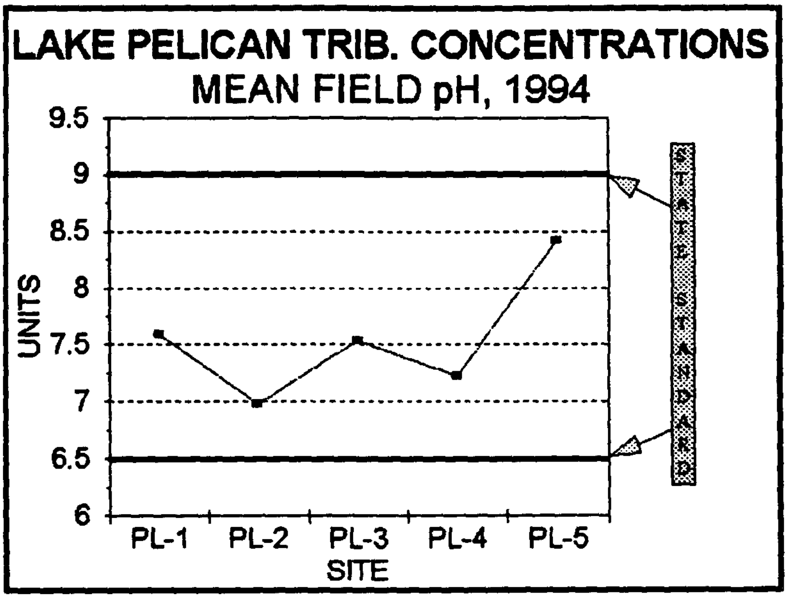


Figure 44. Mean Field pH

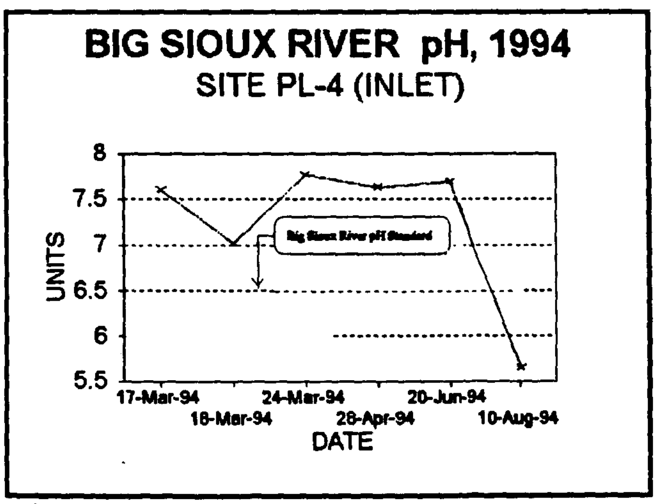


Figure 45. Site PL-4 pH

The only time a pH result fell below the state water quality standard was on August 10, 1994, at Site PL-4 (Big Sioux River inlet) (Figure 45). The sample on that date was collected at peak flow following a major storm event. Because the Big Sioux River in this segment is designated as a source of domestic drinking water, it has a lower pH standard of 6.25. The pH result on August 10, 1994, was 5.6. Because of the low pH value, a second and third sample were tested on site. The results of the additional samples were also 5.6. Other than the one time event on August 10, 1994, all pH values for the tributary sites were within the state standard range.

ALKALINITY AND SOLIDS PARAMETERS

ALKALINITY

The alkalinity of water refers to the quantities of different compounds that shift the pH level to the alkaline side of neutrality. Increased alkalinity is generally the result of increased levels of bicarbonates, but is expressed as a sum of hydroxide, carbonate, and bicarbonate. Carbonate and bicarbonate are common in water because carbonate minerals are common in nature. On the other hand, hydroxides generally do not contribute significantly to alkalinity levels. In general, the alkalinity of water is directly related to the geography of an area. Expected total alkalinities for water, in nature, range from 20 to 200 mg/L.

The mean concentrations of alkalinity at the tributary stream sites indicated that Site PL-3 (Foley Road) had the highest concentration of alkalinity, followed by Site PL-1 (State Park). (Figure 46.). Although the water at these two sites had the highest concentration of alkalinity, it only contributed 7.74% of the total alkalinity for the Pelican Lake hydrologic system (Figure 47).

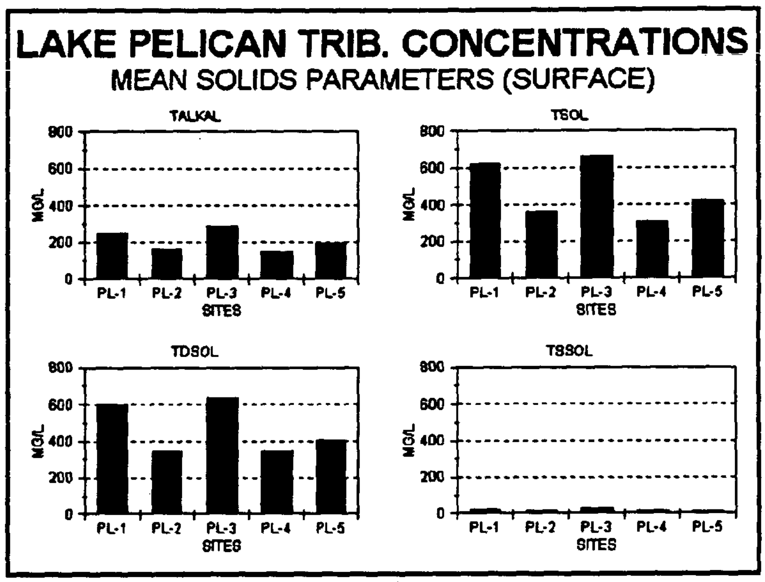


Figure 46. Mean Solids Parameters

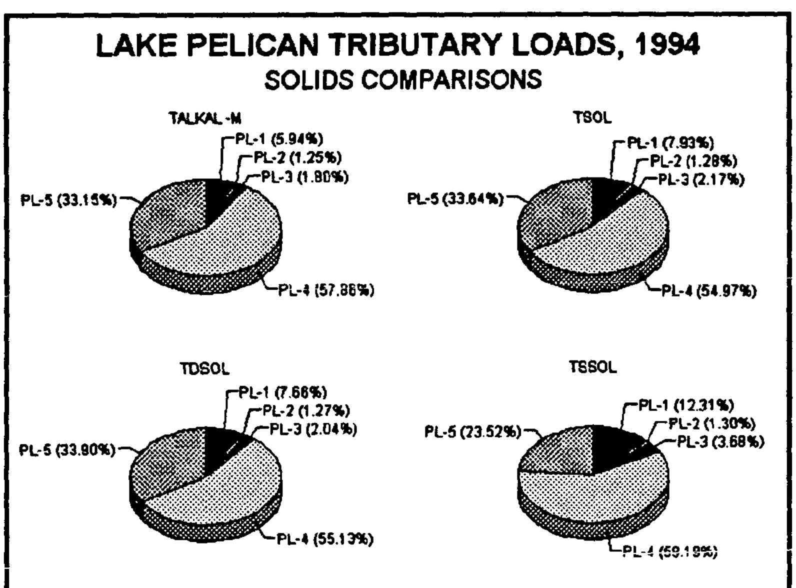


Figure 47. Solids Comparisons

The water at Site PL-4 (Big Sioux River inlet), which actually had the lowest concentration of alkalinity (Figure 46), contributed the most total alkalinity to the system (Figure 47). In addition, the water from Site PL-5 (Big Sioux River outlet) allowed more total alkalinity to exit the Pelican Lake system than the entire immediate watershed contributed (Figure 47).

TOTAL SOLIDS and TOTAL DISSOLVED SOLIDS

Total solids are all the materials, suspended and dissolved, present in water. These are the materials left after the water from a sample has been evaporated off. Total dissolved solids (mg/L) include salts and organic residue which pass through with a filtered water sample. Total suspended solids are the solids retained on the filter. Total dissolved solids results for water samples can be determined by subtracting suspended solids results from total solids results.

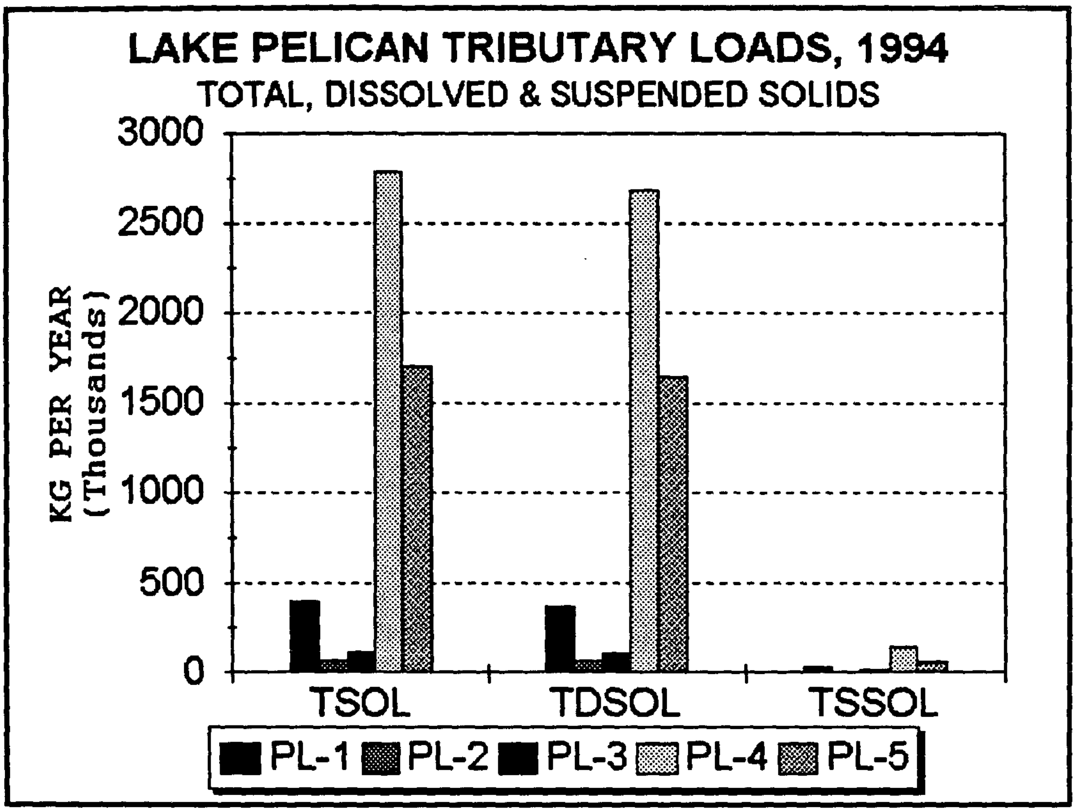


Figure 48. Total, Dissolved & Suspended Solids Loads

The water at Site PL-3 (Foley Road) exhibited the highest total solids (TSOL) and dissolved solids (TDSOL) concentrations during the study period, followed by the water at Site PL-1 (State Park) (Figure 46). While Site PL-3 had the highest concentrations of these parameters, Site PL-4 (Big Sioux River inlet) had the highest loadings of total and total dissolved solids (Figure 48). Of the immediate watershed sites, the water at Site PL-1 (State Park) contributed more kilograms per year of total and total dissolved solids than the water at Sites PL-2 and PL-3 combined (Figure 47).

TOTAL SUSPENDED SOLIDS

Total Suspended Solids include organic and inorganic materials that are not dissolved. This parameter can indicate the sediment load into a body of water and possible problems for a biological community. The analysis for suspended solids does not include a measure of larger particles that are moved along a stream bed during high flows (bed load).

The total suspended solids parameter in this study is used as an indicator of sedimentation in Pelican Lake. The water at Site PL-4 (Big Sioux River inlet) contributed 141,525 kg (312,004 lbs) per year of total suspended solids to Pelican Lake during the study period. This was in contrast to the 41,341 kg (91,140 lbs) per year that the entire immediate watershed (Sites PL-1, PL-2, and PL-3) contributed (Figure 49). This data indicates that the Big Sioux River should be the main focus for the reduction of sediment loading to Pelican Lake.

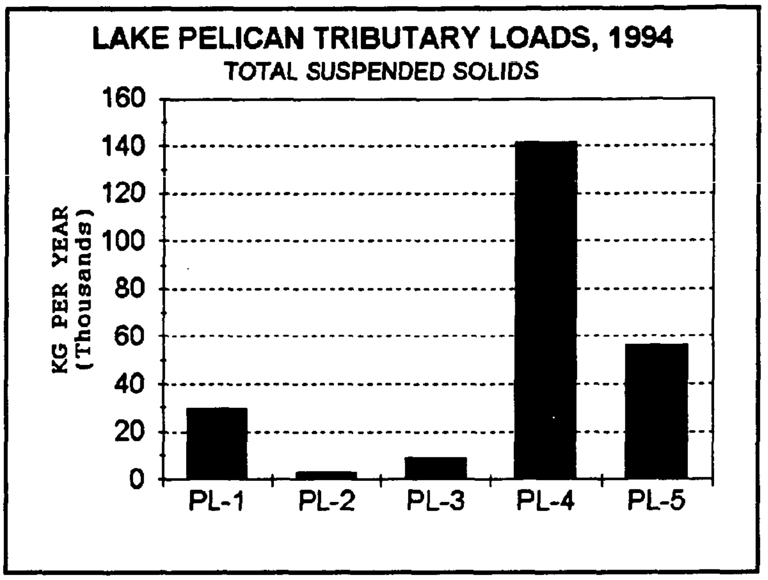


Figure 49. Total Suspended Solids

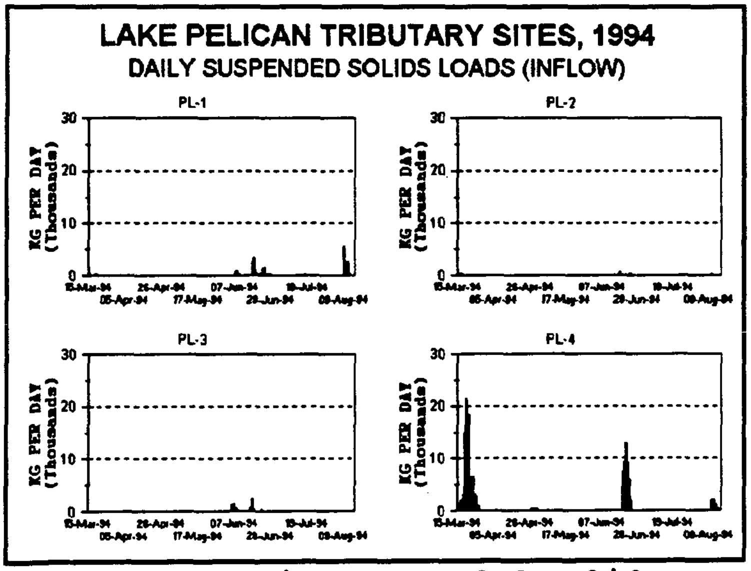


Figure 50. Daily Suspended Solids

The greatest inflow of total suspended solids from Site PL-4 occurred during high flow events, and in particular during snowmelt runoff. This was in contrast to the timing of the major inflow of total suspended solids from the immediate watershed (Sites PL-1, PL-2, and PL-3) which occurred after snowmelt runoff during rainstorm events (Figure 50).

The main flow of water out of Pelican Lake at Site PL-5 (Big Sioux River outlet) occurred mainly after snowmelt runoff (Figure 51).

The loading of total suspended solids into Pelican Lake from all tributary sites was 182,866 kg (403,144 lbs) per year. The loading of total suspended solids which flowed out of the lake Site PL-5 (Big Sioux River outlet) was 56,250 kg (124,008 lbs) per year. Consequently, the loading of total suspended solids retained in Pelican Lake was 126,616 kg (279,136 pounds) per year.

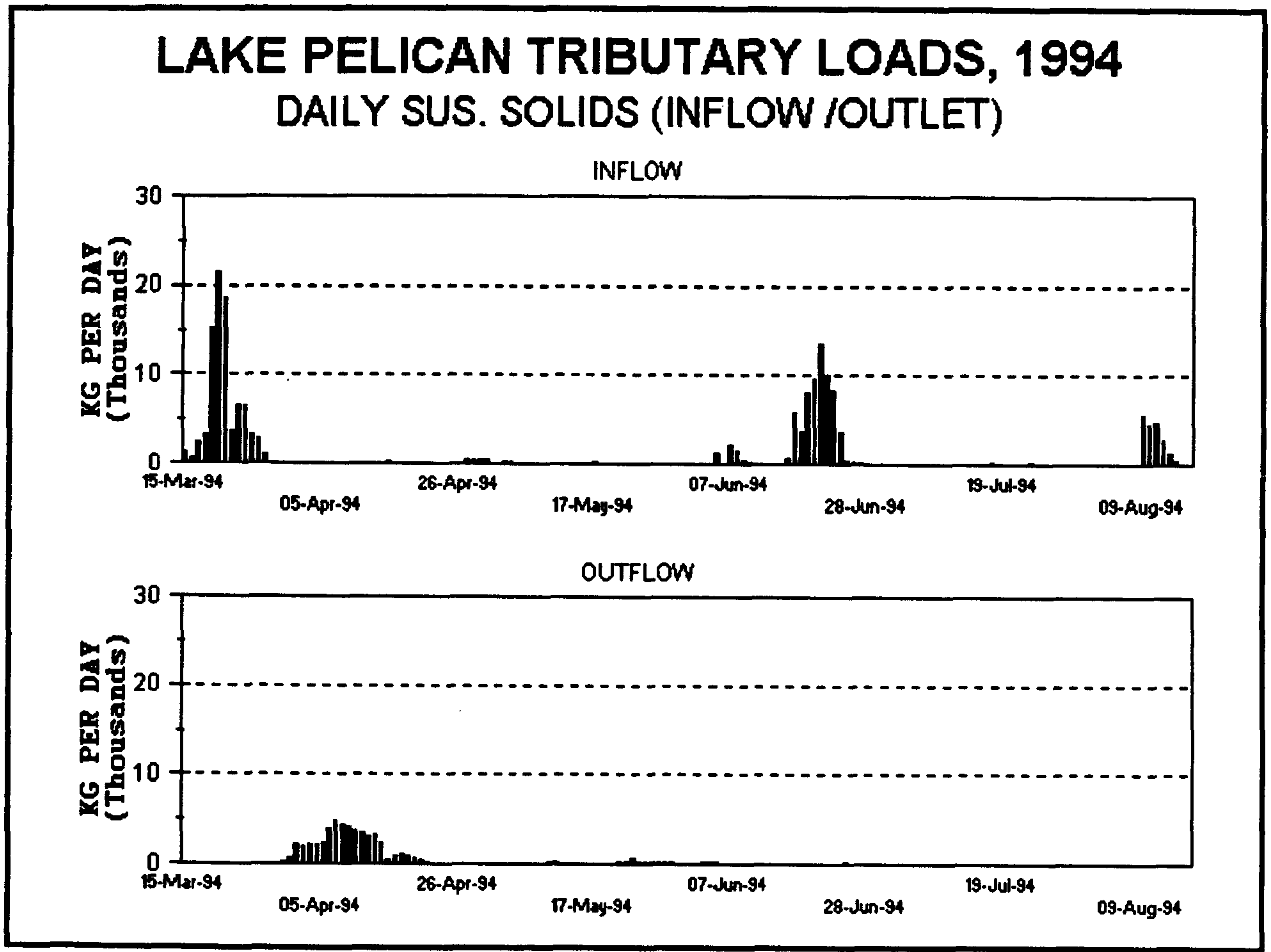


Figure 51. Daily Suspended Solids (Inflow/Outflow)

SEDIMENTATION OF PELICAN LAKE

The total suspended solids loadings for the tributary sites were used to calculate the sedimentation of Pelican Lake over the study period. Separate analyses of Site PL-4 (Big Sioux River inlet), the immediate watershed (Sites PL-1, PL-2, PL-3), and total residual suspended solids (PL-1+ PL-2 + PL-3 + PL-4 minus PL-5), were performed as a comparison of sediment deposition. The following calculations were used to determine sedimentation rates. Top sediment was not calculated due to it's distinct characteristics in density and texture that differ from the standard compacted sediment that it becomes over time as a result of pressure and decomposition.

Standards for density of sediment were obtained from *Reservoir Sedimentation, Technical Guide for Bureau of Reclamation, U.S. Department of the Interior, Bureau of Reclamation. Pemberton and Strand, 1982.*

For compacted sediment a density of 70 lbs per cubic foot was used in the following calculations.

A total of 126,616 kg (279,136 pounds) of sediment was deposited in Pelican Lake during the study period. This would in time represent 147 cubic yards of compacted sediment. In addition to total suspended solids loading, stream bedload was calculated based on streambed conditions and particulate composition. A standard of 5 to 15 percent of the suspended solids load was used for the conditions in the Pelican Lake watershed. Based on these factors, the stream bed load to Pelican Lake during the study period would range from 7.3 to 22.0 cubic yards of sediment.

The annual sedimentation of Pelican Lake, taking into account both the total suspended solids loading and the stream bed load, would equal between 154.3 and 169.0 cubic yards of sediment per year.

The following two analyses do not account for outflow from Pelican Lake.

The inflow of water at Site PL-4 (Big Sioux River inlet) accounted for the greatest contribution of total suspended solids to Pelican Lake. Site PL-4 contributed 141,525 kg (312,004 lbs) per year of suspended solids to Pelican Lake during the study period. This is equivalent to 164 cubic yards per year of compacted sediment over time.

In comparison, the flow of water from the immediate watershed sites (PL-1, PL-2, and PL-3) as a whole contributed 41,341 kg (91,140 lbs) per year of total suspended solids to the lake. This would represent 48 cubic yards of compacted sediment over time. In total, the suspended solids loading to Pelican Lake from the Big Sioux River and the immediate watershed over the study period represented a loading of 212 cubic yards of compacted sediment over time.

The flow of water into Pelican Lake at Site PL-4 (Big Sioux River inlet) represents the most significant source of potential sedimentation and should be the primary focus of a sediment control program.

NUTRIENT PARAMETERS

The concentration data for the stream tributary sites (Figure 52) indicated that nitrate plus nitrite (NO2 + NO3) concentrations were highest at Site PL-3 (Foley Road), while total Kjeldahl nitrogen (TKN), total phosphate (TPO4) , and total dissolved phosphate (TDPO4) were highest at Site PL-2 (Air Haven) (Figure 52).

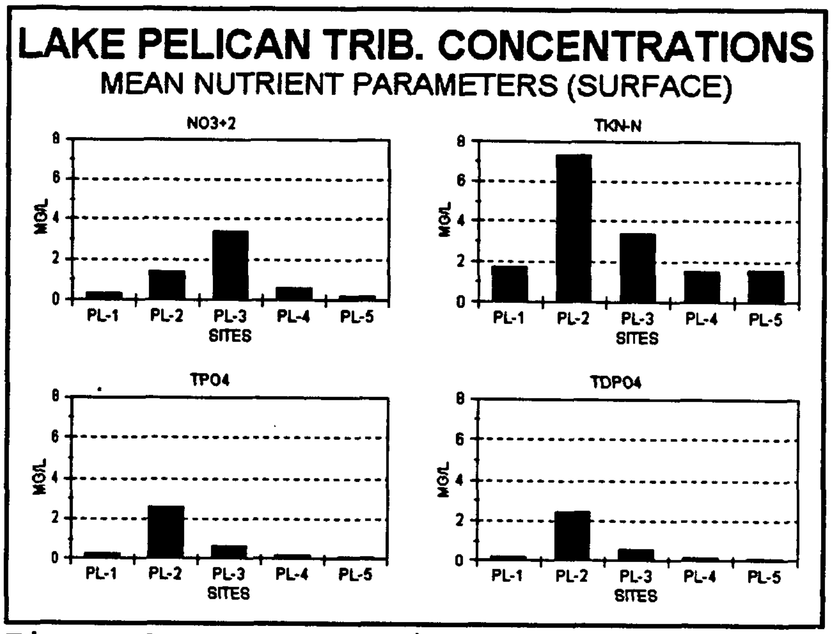


Figure 52. Mean Nutrient Parameters

While the immediate watershed sites (PL-1, PL-2, and PL-3) showed the highest concentrations of nutrients, Site PL-4 (Big Sioux River inlet) exhibited the greatest loads (Figure 53). The higher nutrient concentrations at the immediate watershed sites may have been caused by the closer proximity of nonpoint sources in the immediate watershed to the lake.

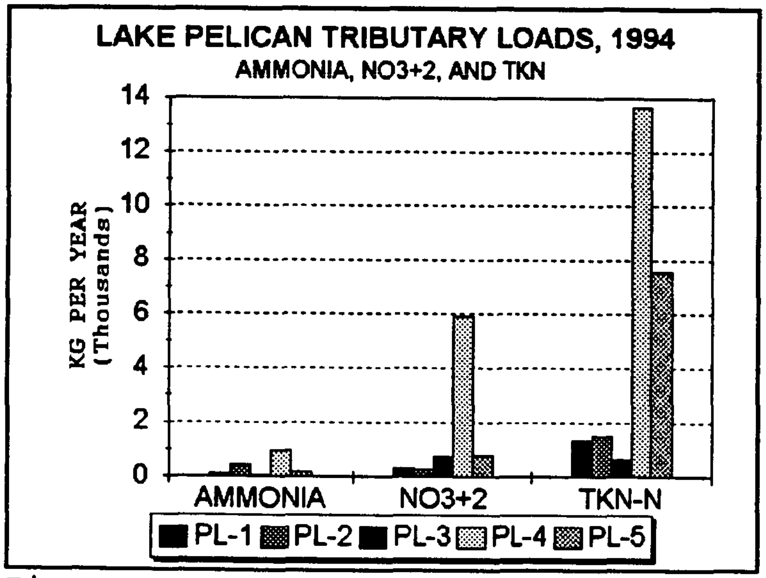


Figure 53. Ammonia, NO3+2 and TKN

The nutrient loadings are explained in greater detail later in this section.

AMMONIA

Ammonia is generated by bacteria as a primary end product of the decomposition of organic matter. Ammonia is the form of nitrogen directly available to plants as a nutrient for growth. High ammonia concentrations indicate pollution from organic sources.

The greatest loading of ammonia came from the inflow of water at Site PL-4 (Big Sioux River inlet) which contributed 951 kg (2,097 lbs) per year during the study period (Figure 53). Due to the ready availability of this nutrient to aquatic plants, it is an important parameter to control during an in-lake nutrient reduction program. Ammonia loadings were also very high from the inflow of water at Site PL-2 (Air Haven) which contributed 429.85 kg (948 lbs) per year during the study period. The ammonia loading from Site PL-2 was the largest among the immediate watershed sites (PL-1, PL-2, and PL-3) (Figure 54).

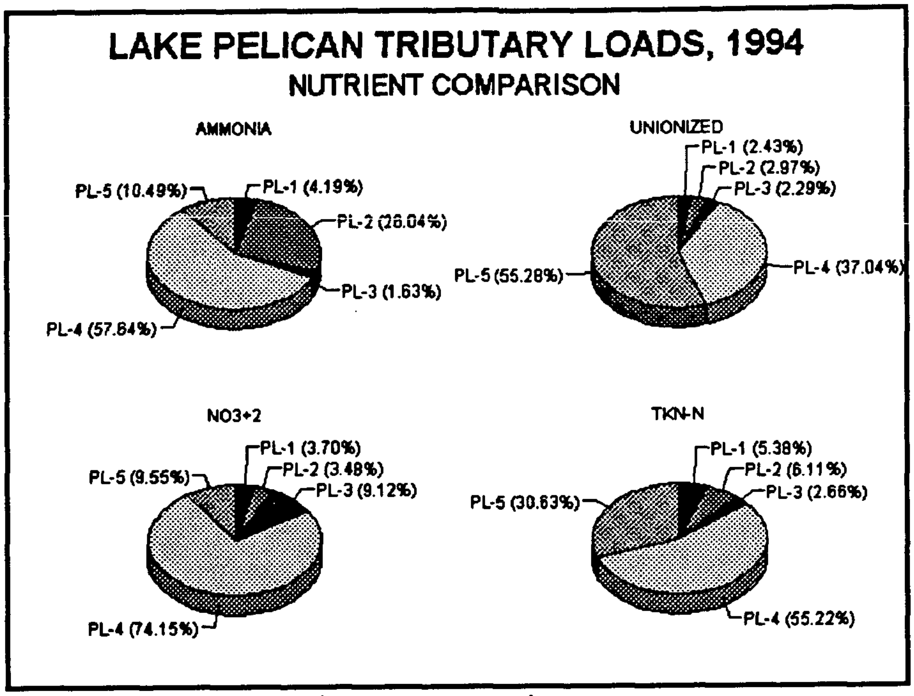


Figure 54. Nutrient Comparison

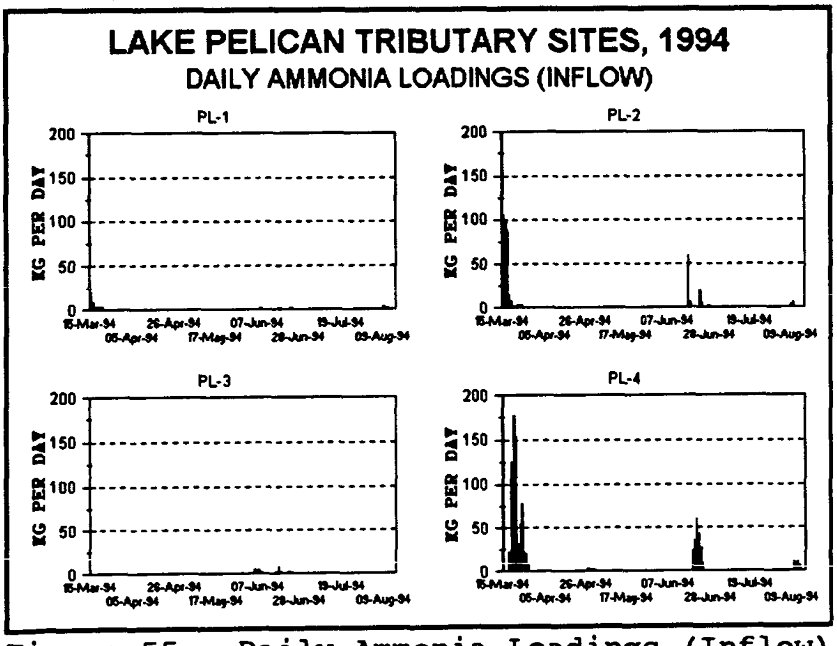


Figure 55. Daily Ammonia Loadings (Inflow)

It was shown during the study that the major loadings of ammonia occurred during high flow periods, mainly during snowmelt runoff (Figure 55).

This was true for site PL-4 (Big Sioux River inlet) as well as the immediate watershed sites (PL-1, PL-2, and PL-3).

A comparison of the times when ammonia entered and exited Pelican Lake indicates a distinct trend (Figure 56). There were major inflows of ammonia loadings during snowmelt runoff and following high flow storm events.

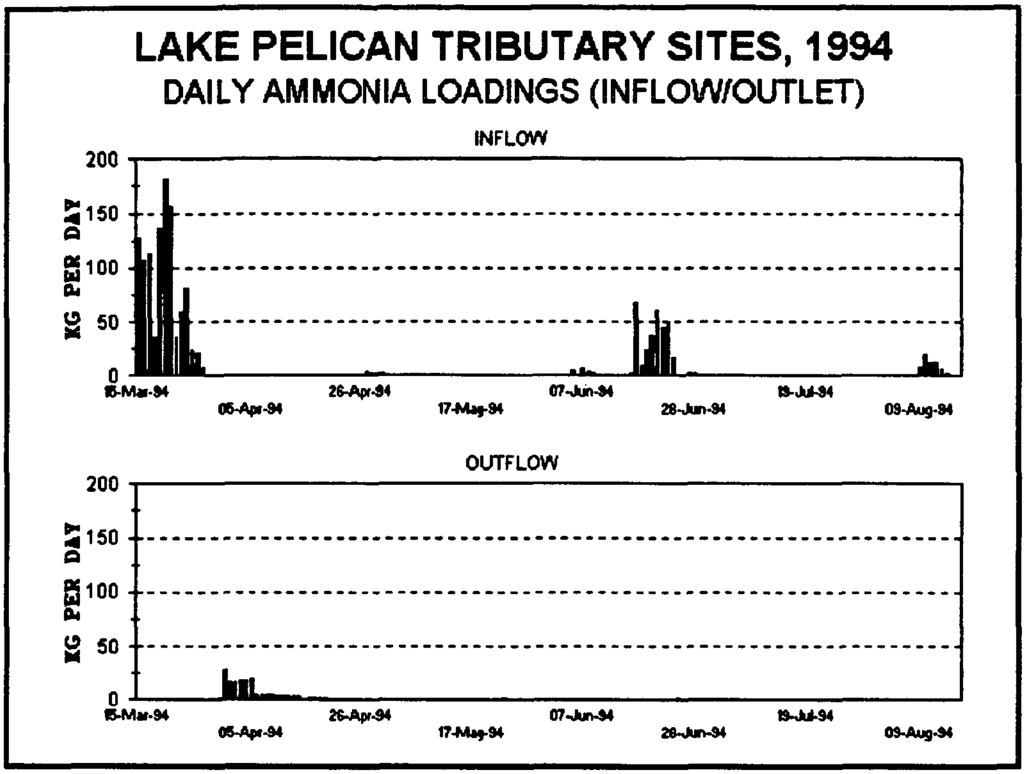


Figure 56. Daily Ammonia Loadings (Inflow/Outflow)

The only significant release of ammonia from the lake, however, occurred immediately following the snowmelt runoff. This indicated that ammonia entering Pelican Lake after the snowmelt runoff was being incorporated into the nitrogen cycle of the lake.

The total loading of ammonia to Pelican Lake can be calculated by taking the sum of all inflowing Sites (PL-1 + PL-2 + PL-3 + PL-4 =1,517.34 kg/year) and subtracting the outflow from Site PL-5, Big Sioux River Outlet (173.22 kg/year). This results in a total deposition of 1,344.12 kg (2,963 lbs) per year of ammonia into Pelican Lake.

UN-IONIZED AMMONIA

Ammonia in water is present primarily as ammonia (NH_4+) and ammonium (NH_4OH), the latter being highly toxic to many organisms and fish. The proportion of NH_4+ to NH_4OH is dependent on dissociation dynamics which are governed by pH and temperature. The approximate ratio of NH_4+ to NH_4OH is as follows:

pH 6	3000:1
pH 7	300:1
pH 8	30:1
pH 9.5	1:1

Because nitrate (NO_3-) must be reduced to NH_4+ before it can be assimilated by plants, ammonia is an energy-efficient source of nitrogen for plants. The energy required to assimilate nitrogen is lowest for NH_4-N and increases for NO_3-N. Among blue-green algae, highest growth rates occur with NH_4-H as the nitrogen source at many different light intensity levels (Wetzel, 1983).

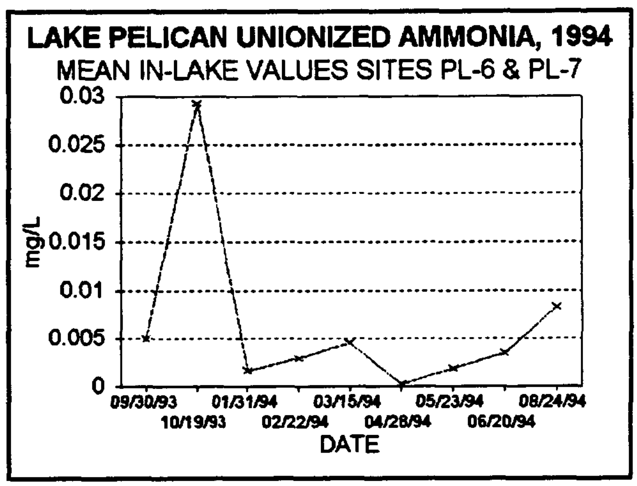


Figure 57. Unionized Ammonia Sites PL-6 & PL-7

The un-ionized ammonia (NH_4OH) parameter showed the effect the difference in pH had on the nutrients entering and leaving Pelican Lake (Figure 54). The major source of ammonia and un-ionized ammonia was the water flowing into Pelican Lake at Site PL-4 (Big Sioux River inlet) which had a yearly mean pH of 7.23. The water flowing out of Pelican Lake at Site PL-5 (Big Sioux River outlet) had a yearly mean pH of 8.43 (Figure 44). The change that occurred in the pH was based on the interaction of in-lake water with the tributary water. (Figure 10) . This change in pH, from 7.23 to 8.43, is approximately one order of magnitude. This increase in pH caused the dissociation ratio of ammonia to un-ionized ammonia to change from 300 to 1 for the water flowing in at Site PL-4, to 30 to 1 for the water flowing out at Site PL-5 (Figure 57). The change in the dissociation ratio consequently explained the extremely high levels of un-ionized ammonia flowing out of Pelican Lake at Site PL-5 (Figure 54).

The timing of the inflow of un-ionized ammonia indicated that the major input of this constituent occurred during high flow events, which followed both snowmelt runoff and rain storm events. The most significant outflow of un-ionized ammonia occurred immediately following snowmelt runoff, with lesser outflows occurring throughout the year. These lesser outflows were not dependent on high flow events.

TOTAL KJELDAHL NITROGEN (TKN)

Total Kjeldahl nitrogen is used to measure both total nitrogen and organic nitrogen. The amount of ammonia (inorganic) is subtracted from the amount of total Kjeldahl nitrogen to arrive at the amount of organic nitrogen present. Organic forms of nitrogen can be broken down into different compounds which are used by phytoplankton.

Water flowing into Pelican Lake at Site PL-4 (Big Sioux River inlet) was the major source of total Kjeldahl nitrogen (TKN) into the hydrologic system (Figure 53). Water flowing into the lake at Sites PL-1 (State Park) and PL-2 (Air Haven) was approximately equal in loadings of TKN with 1,328.24 kg (2,928 lbs) per year flowing in at Site PL-1 and 1,507.22 kg (3,322 lbs) per year flowing in at Site PL-2. These results coincided with Site PL-2 having the highest concentration of TKN of all the study tributary sites.

The timing of the daily loadings of TKN at the tributary stream sites in the immediate watershed indicated that the inflow at Site PL-2 (Air Haven) had the most significant loadings during snowmelt runoff, while the inflow at Site PL-3 (Foley Road) had the greatest loadings following storm events (Figure 58). This was due to the snow plug in the culverts at Site PL-3 which diverted snowmelt runoff away from Pelican Lake.

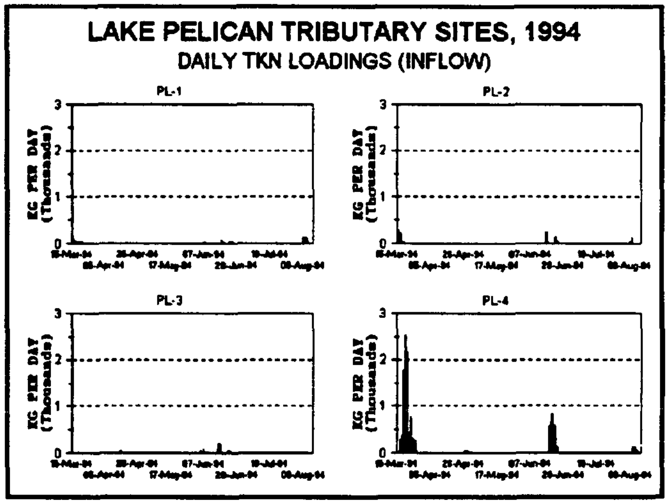


Figure 58. Daily TKN Loadings (Inflow)

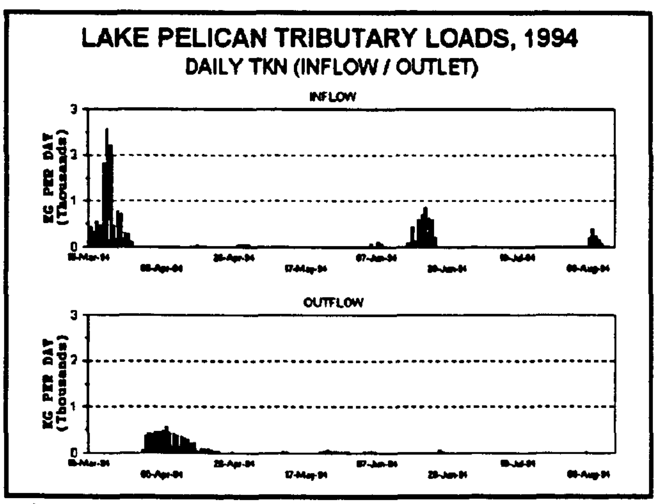


Figure 59. Daily TKN (Inflow/Outflow)

A comparison of the inflow of TKN to the outflow of TKN indicated that the most significant outflow of TKN from Pelican Lake occurred immediately following snowmelt runoff (Figure 59). Less significant outflows of TKN occurred throughout the year, which were not dependent on high flow events.

NITRATE + NITRITE

Nitrate-nitrite nitrogen is often the most abundant inorganic form of nitrogen available in nature. It constitutes the inorganic form of nitrogen assimilated by algae and larger hydrophytes. In natural waters, the concentrations are usually low, around 0.1 mg/L. Some sources of inorganic nitrogen include agricultural runoff, sewage, and atmospheric pollution.

The inflow of water at Site PL-4 (Big Sioux River inlet) was the major source of nitrate-nitrite nitrogen to Pelican Lake (Figure 53). This was due mainly to the large volumes of water flowing in at this site. In the immediate watershed, the water flowing in at Site PL-3 (Foley Road) had the largest loadings of nitrate-nitrite nitrogen (Figure 53). The loadings at Site PL-3 occurred primarily after storm events (Figure 60).

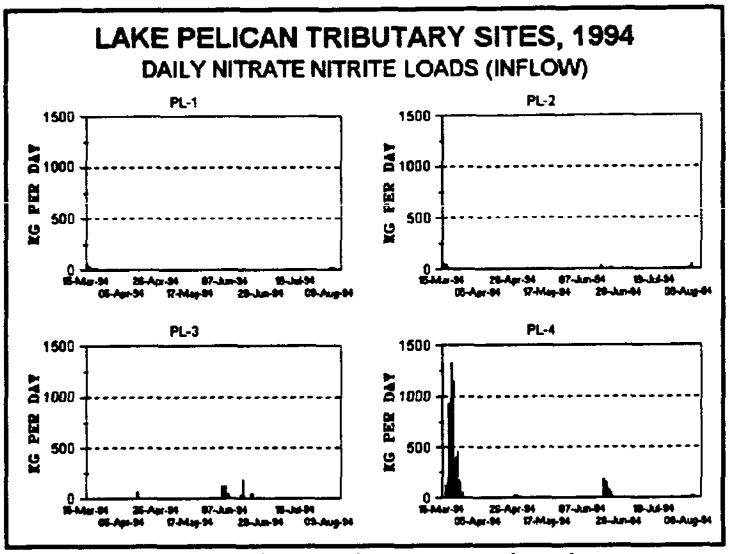


Figure 60. Daily Nitrate Nitrite Loads (Inflow)

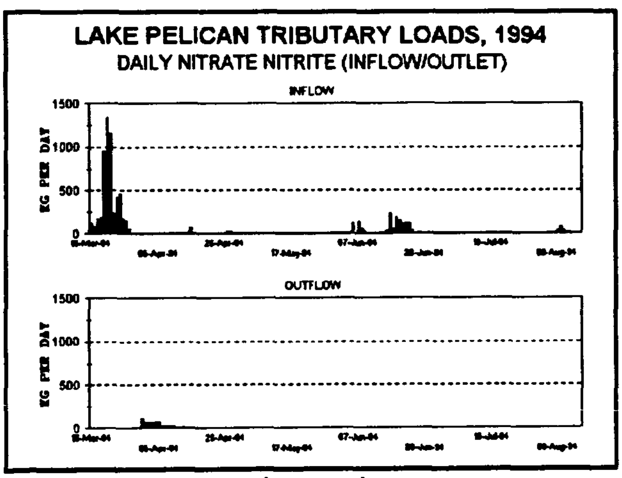


Figure 61. Daily Nitrate Nitrite (Inflow/Outflow)

The major loadings of nitrate-nitrite nitrogen into Pelican Lake occurred during snowmelt runoff (Figure 61). The only significant loadings out of the lake occurred immediately following snowmelt runoff when high volumes of water flowed out. Inflow loadings of nitrate-nitrite nitrogen after snowmelt runoff were incorporated into the nitrogen cycle of the lake. Nitrification occurs most readily in anoxic lakebed sediments which are low in oxygen. During the study period, the water/sediment interface in Pelican Lake did not exhibit anoxic conditions. Consequently, the nitrification / denitrification cycle was inhibited, theoretically resulting in the majority of the nitrate-nitrite nitrogen becoming bound in the lake sediments. This parameter does, in fact, show the greatest retention in Pelican Lake of all the nitrogen parameters (ammonia, TKN, and NO3+NO2) (Figure 54).

TOTAL PHOSPHORUS

Total phosphorus represents all of the phosphorus found in a water sample. Phosphorus is an element which is essential to all life. Not all phosphorus is immediately available to aquatic plants and algae. Soil can bind to phosphorus, causing it to be released only when dissolved oxygen levels are depleted. When phosphorus concentrations are high, nuisance growths of aquatic plants and algae can result. Sources of phosphorus include agricultural activities, sewage, and the decomposition of organic matter.

Water flowing into Pelican Lake at Site PL-4 (Big Sioux River inlet) was the major source of total phosphorus during the study period (Figure 62). For the immediate watershed, water flowing in at Site PL-2 (Air Haven) was the greatest source of phosphorus loading. The water at Site PL-2 also showed the highest concentration of total phosphorus (Figure 52). However, by comparison, the immediate watershed sites (PL-1, PL-2, and PL-3) collectively yielded only 999.33 kg (2,203 lbs) per year of total phosphorus, while Site PL-4 yielded 2090.13 kg (4,608 lbs) per year.

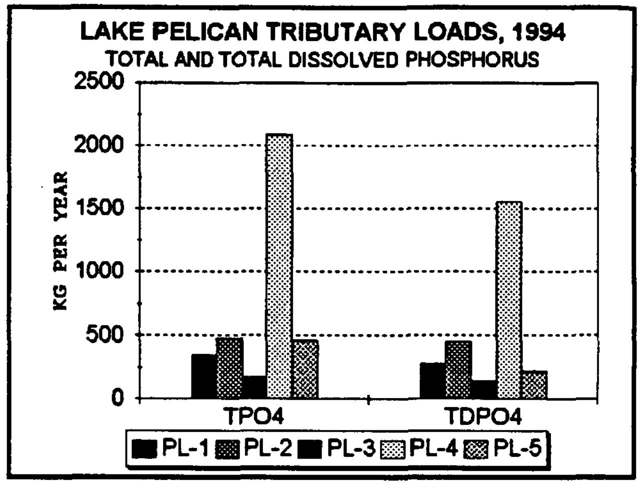


Figure 62. Total and Total Dissolved Phosphorus

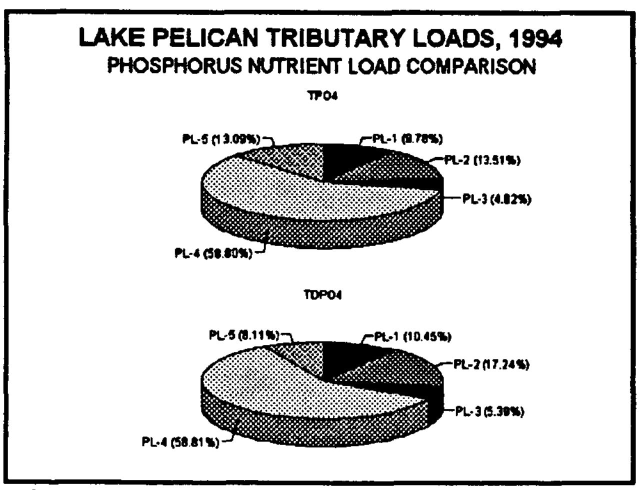


Figure 63. Phosphorus Nutrient Comparison

The loading of phosphorus from both the immediate watershed and the Big Sioux River watershed together was 3,089 kg (6,810 lbs) per year. The outflow of total phosphorus at Site PL-5 (Big Sioux River outlet) was only 465.24 kg (1,026 lbs) per year, which resulted in a total phosphorus loading to the lake of 2,624 kg (5,785 lbs) per year. As can be seen from Figure 63, only 13% of the total phosphorus loading to the lake flowed out past Site PL-5 (Big Sioux River Outlet).

The timing of the total phosphorus loading to the lake indicated that the largest portion occurred during snowmelt runoff (Figure 64).

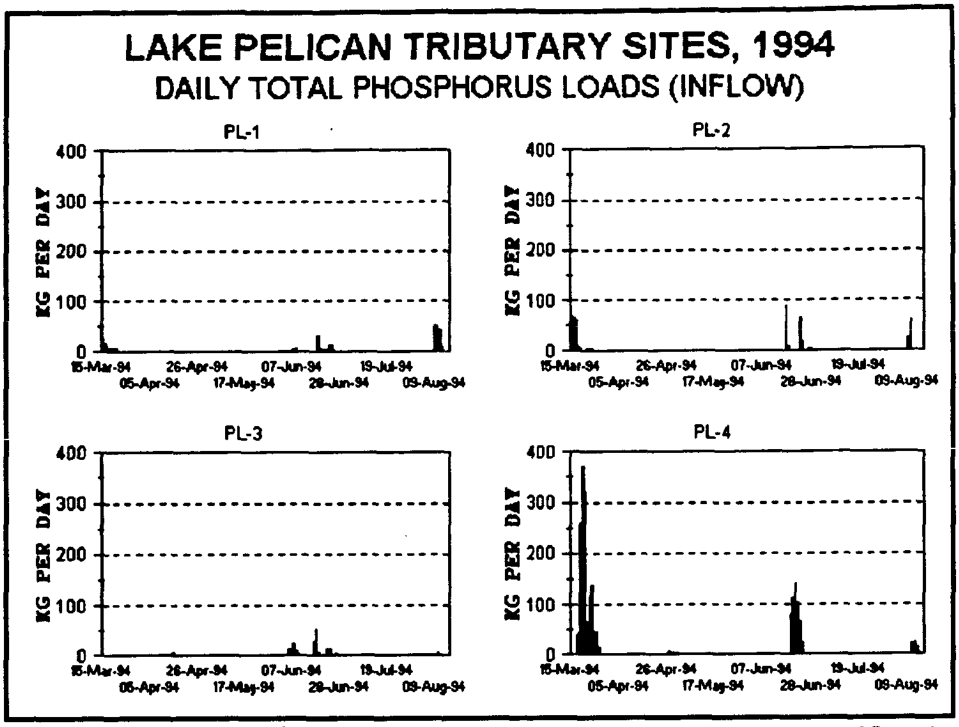


Figure 64. Daily Total Phosphorus Loads (Inflow)

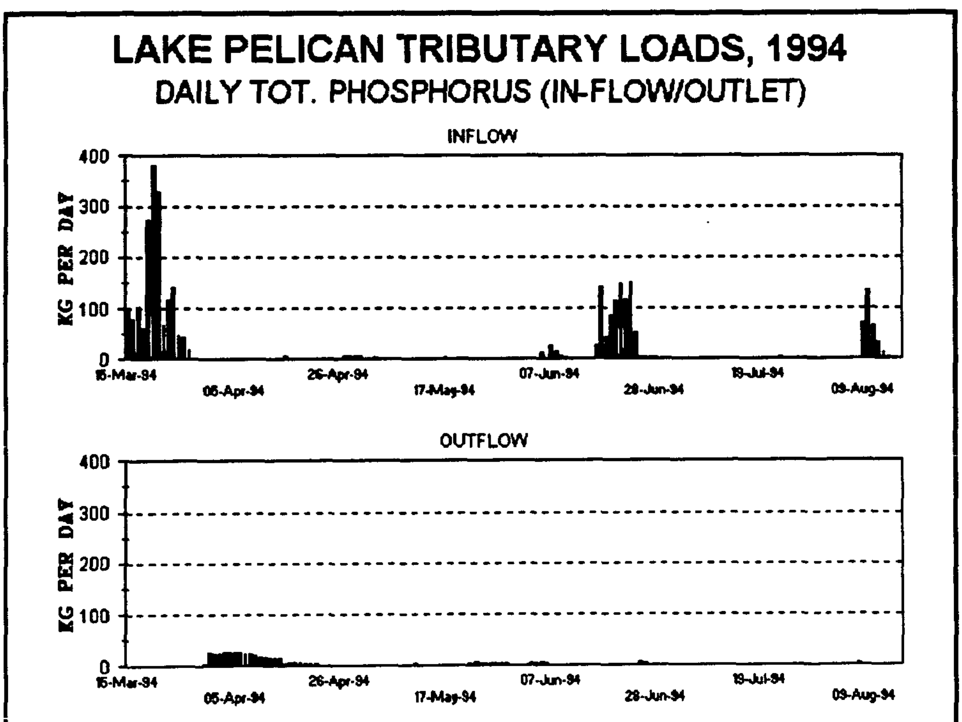


Figure 65. Daily Tot. Phosphorus (Inflow/Outflow)

The only appreciable flow of phosphorus loading out of the lake occurred immediately after the snowmelt runoff, during the period of high flow at Site PL-5 (Big Sioux River outlet)(Figure 65).

TOTAL DISSOLVED PHOSPHORUS

The major loadings of total dissolved phosphorus (TDPO4) to Pelican Lake came from the water that flowed in at Site PL-4 (Big Sioux River inlet) (Figure 62). The water that flowed in at Site PL-2 (Air Haven) showed the greatest loadings of the immediate watershed sites (PL-1, PL-2, and PL-3). The total dissolved phosphorus parameter indicated greater incorporation into the Pelican Lake system than did the total phosphorus parameter (Figure 63). This might be explained by greater assimilation of dissolved phosphorus into plants, and its tendency to bind with particulate matter in lake sediments (Wetzel, 1983).

The loading of total dissolved phosphorus into Pelican Lake from all the tributary stream sites during the study period was 2,434.63 kg (5,367 lbs) per year. (Figure 62). The total loading out of the lake at Site PL-5 (Big Sioux River outlet) was 214.89 kg (474 lbs) per year. This resulted in an overall loading to the lake of 2,219.74 kg (4,894 lbs) per year.

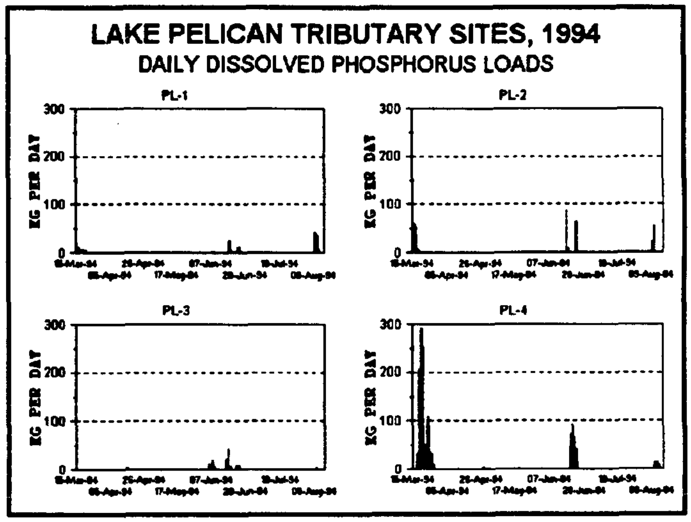


Figure 66. Daily Diss. Phosphorus Loads

The timing of the inflow of total dissolved phosphorus indicated that it entered the lake mainly during high flow events, typically following snowmelt or rain storms (Figure 66). The most significant loss of total dissolved phosphorus from Pelican Lake occurred immediately after snowmelt runoff, with less significant loadings flowing out of the lake later in the year (Figure 67). This analysis shows site PL-4 (Big Sioux River Inlet) had the greatest percentage of input 58.81% with the immediate watershed sites contributing 33.08% of the total dissolved phosphorus through the Pelican Lake system (Figure 63).

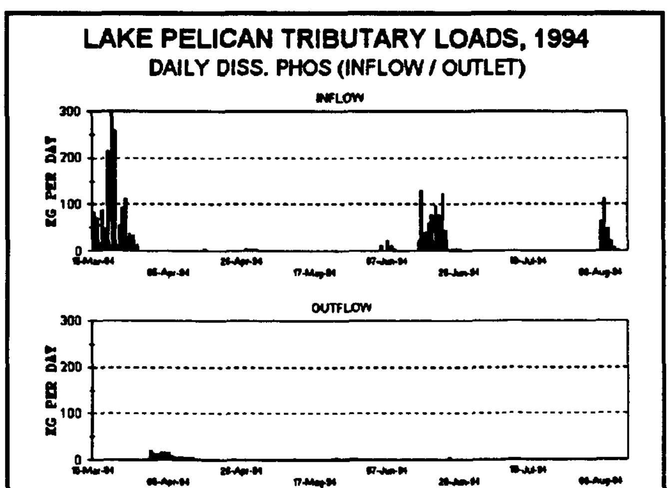


Figure 67. Daily Diss. Phosphorus (Inflow/Outflow)

TRIBUTARY STREAM ANALYSIS

Solids

The greatest total suspended solids (TSS) loadings were monitored at Site PL-4, Big Sioux River inlet (approximately 141,525 kg/year or 312,004 lbs/year) (Figure 49). The greatest TSS loadings from an immediate watershed site were monitored at Site PL-1, State Park (29,424 kg/year or 64,868 lbs/year). Therefore, the Big Sioux River watershed and the State Park subwatershed are the two watershed areas which should be the focus of a sediment control program.

Nitrogen

The greatest loadings of nitrogen flowed into Pelican Lake at Site PL-4 (Big Sioux River inlet) (Figure 54. Lake Pelican Tributary Loads, Nutrient Comparison). The loading of each nitrogen parameter at Site PL-4 was as follows:

Location	Parameter	Kg/year	Lbs/year
PL-4 (BSR inlet)	Ammonia	951	2,097
PL-4 (BSR inlet)	Nitrate-Nitrite	591	1,303
PL-4 (BSR inlet)	TKN	13,627	30,042

The greatest portion of these loadings occurred immediately following snowmelt runoff (Figures 55, 60, 58. Daily Parameter Loads (Inflow)).

A site by site analysis of nitrogen loadings from the immediate watershed indicated that the greatest loadings for the various nitrogen parameters varied according to location. The analysis indicated that the greatest loadings for each parameter occurred as follows:

Location	Parameter	Kg/year	Lbs/Year
PL-2 (Air Haven)	Ammonia	429	948
PL-3 (Foley Road)	Nitrate-Nitrite	727	1,603
PL-2 (Air Haven)	TKN	1,507	3,322

Reference: Figure 53. Lake Pelican Tributary Loads, Ammonia, NO3+2, and TKN.

From the table above, it can be seen that for the immediate watershed the greatest loadings of organic nitrogen (ammonia and TKN) originated from the PL-2 (Air Haven) subwatershed, while the greatest loadings of inorganic nitrogen (Nitrate-Nitrite) flowed in from the PL-3 (Foley Road) subwatershed.

Phosphorus

The greatest loading of total phosphorus to Pelican Lake during the study period flowed in at Site PL-4, Big Sioux River inlet (2,090.13 kg/year or 4,608 lbs/year) (Figure 62). A review of the results for the immediate watershed indicated that the greatest loading of total phosphorus flowed in at Site PL-2, Air Haven (480.32 kg/year or 1,059 lbs/year).

SAMPLE DATA FOR SITE PL-1 (STATE PARK), 1992

DATE	TIME	SAMP	SITE	CUBIC CALC AVG CFS	FLOWS L/DAY	WTEMP C	AIR TEMP C	DISOX mg/l	FECAL COLIFORM per 100ml	LAB pH	TALKAL -M mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	AMMONIA mg/l	UNIONIZED AMMONIA mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4 mg/l	TDPO4 mg/l
15-Mar-94	1400	GRAB	PL-1	22.1	54093798	3.00	5.00	9.20	10	7.26	93	213	198	15	0.39	0.0008	1.20	2.75	0.476	0.376
16-Mar-94	1600	GRAB	PL-1	13.2	32319271	4.50	4.00	9.00	10	7.42	123	283	274	9	0.26	0.0008	1.00	2.41	0.429	0.330
24-Mar-94	1400	GRAB	PL-1	1.9	4721892	1.00	3.00	12.60	10	7.76	289	595	593	2	0.02	0.0001	0.10	1.25	0.170	0.136
31-Mar-94	1115	GRAB	PL-1	1.1	2691234	5.50	10.00	12.00	10	8.00	357	714	712	2	0.02	0.0003	0.10	1.13	0.100	0.073
06-Apr-94	1230	GRAB	PL-1	0.8	1957261	6.00	6.00	10.80	10	7.85	357	712	709	3	0.02	0.0002	0.10	1.01	0.080	0.073
13-Apr-94	1130	GRAB	PL-1	0.5	1198822	10.00	14.00	9.90	10	7.88	361	779	777	2	0.02	0.0003	0.10	0.99	0.060	0.057
15-Apr-94	1245	GRAB	PL-1	1.0	2544439	10.00	7.50	10.50	-	8.14	359	797	778	19	0.02	0.0005	0.10	1.35	0.126	0.093
02-May-94	1230	GRAB	PL-1	1.5	3718796	8.50	12.00	10.40	60	7.23	357	772	766	6	0.02	0.0001	0.10	1.19	0.160	0.150
05-Jun-94	1345	GRAB	PL-1	0.3	636110	27.50	26.00	4.70	-	7.58	130	904	848	56	0.13	0.0033	0.40	2.80	0.456	0.005
16-Jun-94	1430	GRAB	PL-1	0.1	171260	16.50	16.00	5.50	13000	7.44	218	602	482	120	0.08	0.0007	0.20	2.07	0.713	0.626
10-Aug-94	1000	GRAB	PL-1	31.9	78094710	15.70	17.00	5.70	25000	6.92	123	511	480	31	0.02	0.0000	0.30	1.66	0.626	0.513
MINIMUM				0.1	171260.3	1.0	3.0	4.7	0.0	6.9	93.0	213.0	198.0	2.0	0.0	0.0	0.1	1.0	0.1	0.0
MAXIMUM				31.9	78094709.8	27.5	26.0	12.6	25000.0	8.1	361.0	904.0	848.0	120.0	0.4	0.0	1.2	2.8	0.7	0.6
MEAN				6.8	16558872.0	9.8	11.0	9.1	3465.5	7.6	251.5	625.6	601.5	24.1	0.1	0.0	0.3	1.7	0.3	0.2

SAMPLE DATA FOR SITE PL-2 (AIR HAVEN), 1994

DATE	TIME	SAMP	SITE	CUBIC CALC AVG CFS	FLOWS L/DAY	WATER TEMP	AIR TEMP	DISSOX.	FECAL COLIFORM per 100ml	LAB pH	TALKAL mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	AMMON mg/l	UNIONIZED AMMONIA mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4 mg/l	TDPO4 mg/l
15-Mar-94	1230	GRAB	PL-2	13.00	31805490	1.0	4.5	7.00	850	6.79	86	209	192	17	3.33	0.0018	1.80	9.04	2.130	1.960
16-Mar-94	1445	GRAB	PL-2	11.30	27646310	2.0	6.0	6.00	500	6.96	108	256	244	12	3.54	0.0032	1.80	9.13	2.320	2.160
20-Jun-94	1315	GRAB	PL-2	0.03	73397	22.5	21.0	0.60	480	7.44	320	571	547	24	0.04	0.0005	0.10	5.25	3.050	3.110
10-Aug-94	1100	GRAB	PL-2	8.94	21872391	14.9	14.5	5.29	190000	6.74	132	417	407	10	0.31	0.0005	1.90	6.01	2.710	2.500
MINIMUM				0.03	73397	1.0	4.5	0.60	480	6.74	86	209	192	10	0.04	0.0005	0.10	5.25	2.130	1.960
MAXIMUM				13.00	31805490	22.5	21.0	7.00	190000	7.44	320	571	547	24	3.54	0.0032	1.90	9.13	3.050	3.110
MEAN				8.32	20349397	10.1	11.5	4.72	47958	6.98	162	363	348	16	1.81	0.0015	1.40	7.36	2.553	2.433

SAMPLE DATA FOR SITE PL-3 (FOLEY ROAD), 1994

DATE	TIME	SAMP	SITE	CUBIC CALC AVG CFS	FLOWS L/DAY	WATER TEMP	AIR TEMP	DISOX	FECAL COLIFORM per 100ml	LAB pH	TALKAL mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	AMMON mg/l	UNIONIZED AMMONIA mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4 mg/l	TDPO4 mg/l
15-Apr-94	1130	GRAB	PL-3	3.29	8054129	8.00	15.00	11.60	-	8.09	374	871	844	27	0.02	0.0004	8.60	4.82	0.729	0.653
26-Apr-94	1730	GRAB	PL-3	0.39	951718	6.00	8.00	11.80	130	7.73	417	881	878	3	0.02	0.0001	0.40	2.64	0.353	0.323
02-May-94	1145	GRAB	PL-3	0.25	611644	8.50	11.00	9.60	10	7.50	420	739	737	2	0.02	0.0001	0.10	2.39	0.240	0.233
05-Jun-94	1245	GRAB	PL-3	5.01	12257346	22.00	26.00	5.00	-	7.29	96	574	462	112	0.36	0.0032	9.50	4.38	1.050	0.852
16-Jun-94	1330	GRAB	PL-3	12.00	29358913	16.00	17.00	7.00	11000	7.61	268	568	547	21	0.06	0.0007	1.20	3.00	0.864	0.723
10-Aug-94	1215	GRAB	PL-3	2.49	6091975	17.00	18.80	6.10	3400	7.00	140	342	335	7	0.02	0.0001	0.40	2.88	0.876	0.773
MINIMUM				0.25	611644	6.00	8.00	5.00	0	7.00	96	342	335	2	0.02	0.0001	0.10	2.39	0.240	0.233
MAXIMUM				12.00	29358913	22.00	26.00	11.80	11000	8.09	420	881	878	112	0.36	0.0032	9.50	4.82	1.050	0.852
MEAN				3.91	9554288	12.92	15.97	8.52	2423	7.54	286	663	634	29	0.08	0.0008	3.37	3.35	0.685	0.593

SAMPLE DATA FOR SITE PL-4 (BIG SIOUX RIVER, INLET), 1994

DATE	TIME		SITE	CUBIC CALC AVG CFS	FLOWS L/DAY	WATER TEMP	AIR TEMP	DISOX	FECAL COLIFORM per 100ml	LAB pH	TALKAL mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	AMMON mg/l	UNIONIZED AMMONIA mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4 mg/l	TDPO4 mg/l
17-Mar-94	1230	GRAB	PL-4	56.47	138158154	0.5	10.0	11.70	10	7.60	106	258	244	14	0.16	0.0005	0.90	2.00	0.286	0.226
18-Mar-94	1130	GRAB	PL-4	77.605	189866540	0.5	8.0	10.60	-	7.02	119	276	260	16	0.09	0.0001	0.90	2.01	0.233	0.183
24-Mar-94	1700	GRAB	PL-4	209.8	513291671	1.0	1.0	11.20	10	7.77	162	308	295	13	0.15	0.0008	0.90	1.40	0.270	0.213
28-Apr-94	1300	GRAB	PL-4	19.425	47524741	4.5	0.0	10.50	1100	7.63	285	561	550	11	0.02	0.0001	0.40	0.89	0.090	0.060
20-Jun-94	1630	GRAB	PL-4	209.411	512339952	24.0	26.0	3.50	320	7.69	–	–		18	0.07	0.0018	0.30	1.35	0.216	0.143
10-Aug-94	1345	GRAB	PL-4	29.45	72051667	16.5	20.0	6.20	14000	5.65	193	424	396	28	0.14	0.0000	0.10	1.60	0.283	0.180
MINIMUM				19.4	47524741	0.5	0.0	3.50	0	5.65	0	0	244	11	0.02	0.0000	0.10	0.89	0.090	0.060
MAXIMUM				209.8	513291671	24.0	26.0	11.70	14000	7.77	285	561	550	28	0.16	0.0018	0.90	2.01	0.286	0.226
MEAN				100.4	245538787	7.8	10.8	8.95	2573	7.23	144	305	349	17	0.11	0.0006	0.58	1.54	0.230	0.168

SAMPLE DATA FOR SITE PL-5 (BIG SIOUX RIVER, OUTLET), 1994

DATE	TIME	SAMP	SITE	CUBIC CALC AVG	FLOWS L/DAY	WATER TEMP	AIR TEMP	DISOX	FECAL COLIFORM per 100ml	LAB pH	TALKAL mg/l	TSOL mg/l	TDSOL mg/l	TSSOL mg/l	AMMON mg/l	UNIONIZED AMMONIA mg/l	NO3+2 mg/l	TKN-N mg/l	TPO4 mg/l	TDPO4 mg/l
31-Mar-94	1030	GRAB	PL-5	74.89	183233872	3.5	9.0	14.00	30	7.94	212	458	454	4	0.15	0.0014	0.60	2.02	0.140	0.107
06-Apr-94	1130	GRAB	PL-5	97.88	239470871	4.0	4.0	15.00	10	8.62	186	390	373	17	0.02	0.0009	0.10	2.40	0.107	0.037
13-Apr-94	1230	GRAB	PL-5	54.31	132875996	6.0	15.5	15.00	10	8.85	167	384	360	24	0.02	0.0018	0.10	1.60	0.100	0.020
21-Apr-94	1030	GRAB	PL-5	13.83	33843488	10.2	5.0	8.80	10	8.29	175	420	415	5	0.02	0.0007	0.10	1.16	0.077	0.017
23-May-94	1030	GRAB	PL-5	18.62	45543015	22.0	22.0	6.20	10	8.11	195	412	398	14	0.02	0.0011	0.10	1.30	0.136	0.086
16-Jun-94	1600	GRAB	PL-5	1.96	4800182	20.0	16.0	8.20	100	8.76	200	443	440	3	0.02	0.0037	0.10	1.24	0.116	0.073
MINIMUM				1.96	4800182	3.5	4.0	6.20	10	7.94	167	384	360	3	0.02	0.0007	0.10	1.16	0.077	0.017
MAXIMUM				97.88	239470871	22.0	22.0	15.00	100	8.85	212	458	454	24	0.15	0.0037	0.60	2.40	0.140	0.107
MEAN				43.58	106627904	11.0	11.9	11.20	28	8.43	189	418	407	11	0.04	0.0016	0.18	1.62	0.113	0.057

LAND USES IN THE PELICAN LAKE WATERSHED

An analysis of the Pelican Lake immediate watershed was conducted to arrive at land use acreages. The boundaries of the entire watershed were traced onto aerial section photographs (scale: 8"=1 mile) obtained from the Consolidated Farm Service Agency(CFSA) at Watertown, South Dakota.

Once the watershed area had been determined, a digital planimeter was used to measure various land uses. Cropland fields with acreages indicated on CFSA aerial photos were counted as Agriculture-Cultivated. Hayland, pastureland, and rangeland areas with no field acreages indicated on the photos were counted as Agriculture-Non-cultivated. Farmsteads and lake developments were included as Residential-Low Density, whereas towns were put into a Residential-High Density category. Rivers, lakes, and noncropped wetlands were classified as Water areas. Fields labeled as CRP on the aerial photos were put into a separate Conservation Reserve Program classification. Large field windbreaks or blocks of trees were included in a category called Forest. A final category referred to as Transportation was used to include the land areas taken up by roads. A factor of 16 acres of county, township, or state roads per section was used to calculate the values for the Transportation classification.

As can be seen from Table 17, the great majority of land in the entire immediate watershed is classified as Agriculture-Cultivated, or Cropland (9,153 acres). The second largest category for land use (1,960 acres) is Agriculture-Non-cultivated (Pasture/Range). Significantly smaller acreages are included in the categories for CRP (Conservation Reserve Program), Residential (Farmsteads), Water (Rivers, Lakes, Wetlands), Forest (Windbreaks), and Transportation (Roads). The total acreage for the Pelican Lake watershed is 13,065 acres.

Table 17. Land Use Areas and Percentages (Immediate Watershed)

Land Use	Acres	Percentage
Ag Cultivated (Cropland)	9,153	70%
Ag Non-cultivated (Pasture/Range)	1,960	15%
Ag CRP (Conservation Reserve)	270	2%
Residential (Farmsteads)	851	7%
Residential (Towns)	0	0%
Water (Lakes, Wetlands)	316	2%
Forest (Windbreaks)	189	1%
Transportation (Roads)	326	3%
Totals	13,065	100%

From the above table it can be seen that approximately 13 percent of the immediate watershed is in non-agricultural use (Residential, Water, Forest, and Transportation). Consequently, 87 percent (11,383 acres) of the watershed is in primarily agricultural use.

The large comparative sizes of agricultural land uses in the immediate watershed provide a strong indication why high loadings of solids and nutrients were found in the tributaries during the water quality monitoring portion of the Lake Assessment Project.

AGNPS WATERSHED MODEL

An analysis of the Pelican Lake watershed was conducted utilizing a computer model. The model selected was the Agricultural Nonpoint Source Pollution Model (AGNPS, version 3.65.5). This model was developed by the Agricultural Research Service to analyze water quality of runoff events from watersheds. The model predicts runoff volume and peak rate, eroded and delivered sediment, nitrogen, phosphorus, and chemical oxygen demand (COD) concentrations in the runoff and sediment for a single storm event for all points in the watershed. Proceeding from the headwaters to the outlet, the pollutants are routed in a step-wise fashion so the flow at any point may be examined. This model was intended for watersheds up to 76,000 acres (1900 cells @ 40 acres / cell).

The size of the Pelican Lake watershed and area modeled was approximately 17,000 acres. The watershed was divided into subwatersheds based on flow and drainage patterns. This resulted in the watershed being divided into 12 subwatersheds along with direct overland flow from cells adjacent to Pelican Lake. Nonpoint source (NPS) loadings, feedlot contributions and hydrology were computed for each subwatershed in order to determine the loadings into Pelican Lake. The amounts of NPS loadings deposited in Pelican Lake and transported out of the lake were **not** calculated.

AGNPS Goals

The primary objectives of running AGNPS on the Pelican Lake watershed were to:

1.) Evaluate and quantify the loadings from each subwatershed and their net loading to the lake.
2.) Define critical cells within each subwatershed (high sediment, nitrogen, phosphorus).
3.) Quantify the nutrient loadings from each feedlot and priority rank each feedlot.

The following is a brief overview of each objective.

OBJECTIVE 1 - AGNPS SUBWATERSHED LOADINGS TO PELICAN LAKE

AGNPS data indicates that subwatersheds 10 & 11 have the largest per acre impact on sediment loadings to Pelican Lake ($\geq +1\ \sigma$ (sample standard deviation)). Subwatershed 10 also has elevated nitrogen and phosphorus loadings ($> +1\ \sigma$). Subwatershed 2 appears to have elevated nitrogen and phosphorus loadings. However this can probably be attributed to the high percentage of row crops and level of fertilization (no feedlots present). Comparing the Pelican Lake AGNPS loading data to other lake watersheds (expected critical range), the NPS loadings appear to be high. This can be attributed to the fact that as the size of subwatersheds decrease, the distance from the NPS source to the lake decreases, thereby resulting in higher mean values. Overall, the sediment erosion rates in watersheds 10 & 11 appear to be above normal while the nitrogen and phosphorus loadings in subwatersheds 10 and 2 appear to be above normal. Based upon this analysis, it is recommended that conservation practices be concentrated on subwatersheds 10, 11, and 2.

Table 18. Subwatershed Cross Reference (See Appendix B Figures on Pages B38,B39)

SUBWATERSHED	DRAINAGE AREA	OUTLET CELL #	MONITORING SITE
1	680	170	
2	680	150	
3	720	151	
4	1720	95	
5	720	78	
6	440	268	
7	2760	300	SITE 1 (STATE PARK)
8	920	248	
9	520	225	
10	1800	201	SITE 2 (AIR HAVEN)
11	960	162	SITE 3 (FOLEY ROAD)
12	1240	143	
OUTLET	17000	103	SITE 5 (BSR OUTLET)

Table 19. Tributary Loading - per Acre

SITE	DRAIN AREA (ACRES)	SEDIMENT TON/AC/YR (ANN+1YR)	SEDIMENT TON/AC/YR (25YREVT)	TOT.NITRO TON/AC/YR (ANN+1YR)	TOT.NITRO TON/AC/YR (25YR.EVT)	TOT.PHOS. TON/AC/YR (ANN+1YR)	TOT.PHOS. TON/AC/YR (25YR.EVT)
1	680	.17	.46	.0038	.0030	.00100	.00099
2	680	.21	.51	.0128	.0062	.00279	.00166
3	720	.02	.08	.0078	.0044	.00174	.00110
4	1720	.26	.63	.0077	.0045	.00180	.00132
5	720	.02	.12	.0048	.0028	.00100	.00071
6	440	.32	.80	.0028	.0026	.00084	.00095
7	2760	.17	.47	.0052	.0038	.00136	.00121
8	920	.11	.66	.0051	.0041	.00118	.00128
9	520	.17	.82	.0034	.0052	.00097	.00173
10	1800	.54	1.25	.0095	.0068	.00262	.00231
11	960	.45	.98	.0065	.0050	.00171	.00151
12	1240	.19	.43	.0046	.0029	.00112	.00085
MEAN		.22	.60	.0062	.0043	.00151	.00130
MEDIAN		.18	.57	.0052	.0043	.00127	.00125
SSTD		.16	.33	.0029	.0014	.00065	.00045
MEAN +	1SSTD (σ)	.38	.93	.0091	.0057	.00216	.00175
*EXP.CR RANGE	ITICAL	.10⇒ .18	.40⇒ .89	.002⇒ .003	.002⇒ .003	.0005⇒ .0008	.0005⇒ .0008

* -- Values for smaller subwatersheds will be higher than larger watersheds because of the inverse relationship of loadings to distance from a nonpoint source to the lake.

Table 19. Continued

SITE	DRAINAGE AREA (ACRES)	SEDIMENT TON/AC/YR (ANN.+1YR)	SEDIMENT TON/AC/YR (25YR.EVT)	TOT.NITRO. TON/AC/YR (ANN.+1YR)	TOT.NITRO TON/AC/YR (25YR.EVT)	TOT.PHOS. TON/AC/YR (ANN.+1YR)	TOT.PHOS. TON/AC/YR (25YR.EVT)
1	**680**	**111**	**312**	**2.6**	**2.0**	**0.7**	**0.7**
2	**680**	**142**	**349**	**8.7**	**4.2**	**1.9**	**1.1**
3	**720**	**20**	**55**	**5.6**	**3.2**	**1.3**	**0.8**
4	**1720**	**460**	**1080**	**13.2**	**7.7**	**3.1**	**2.3**
5	**720**	**19**	**88**	**3.5**	**2.0**	**0.7**	**0.5**
6	**440**	**141**	**353**	**1.2**	**1.1**	**0.4**	**0.4**
7	**2760**	**486**	**1296**	**14.3**	**10.5**	**3.8**	**3.4**
8	**920**	**99**	**612**	**4.7**	**3.8**	**1.1**	**1.2**
9	**520**	**87**	**427**	**1.8**	**2.7**	**0.5**	**0.9**
10	**1800**	**981**	**2250**	**17.1**	**12.2**	**4.7**	**4.2**
11	**960**	**433**	**944**	**6.2**	**4.8**	**1.6**	**1.4**
12	**1240**	**241**	**536**	**5.7**	**3.6**	**1.4**	**1.1**
Direct	**1080**	**---**	**---**	**---**	**---**	**---**	**---**
Pelican Lake	**2760**	**---**	**---**	**---**	**---**	**---**	**---**
Total Loads	**17000 13160**	**3220**	**8302**	**84.6**	**57.8**	**21.2**	**18.0**

OBJECTIVE 2 - IDENTIFICATION OF CRITICAL CELLS (25 YEAR EVENT)

Table 20. Identification of Critical Cells (25 Year Event)

Sub Watershed	Drainage Area (Acres)	Num. Cells with Erosion > 3.0 Ton/Ac.	%	Num Cells With Total Nit. >25.0 ppm	%	Num. Cells With Total Phos. >5.0 ppm	%	Num. of Feedlots in Subwatershed
1	680	1	6	0	0	0	0	0
2	680	5	29	0	0	0	0	0
3	720	3	17	3	17	3	17	1
4	1720	0	0	0	0	0	0	3
5	720	0	0	1	6	2	11	1
6	440	3	27	0	0	0	0	0
7	2760	2	3	0	0	0	0	4
8	920	0	0	0	0	0	0	1
9	520	1	8	2	15	2	15	1
10	1800	4	9	1	2	2	4	4
11	960	0	0	3	13	3	13	3
12	1240	2	6	0	0	0	0	1

NUMBER OF CRITICAL CELLS WITHIN 6 CELLS (8000 FEET OR 1.5 MILES) OF LAKE

EROSION	-	16 OUT OF 21	(76%)
NITROGEN	-	7 OUT OF 10	(70%)
PHOSPHORUS	-	9 OUT OF 12	(75%)
FEEDLOTS	-	13 OUT OF 20	(65%)

Table 21. Identification of Critical Areas in Watershed

Priority Erosion Cells	Priority Feedlots	Priority Nitrogen Cells	Priority Phosphorus Cells
14 3.87 ton/ac	#332 (#1 ranked) 76	40 27.25 ppm	40 7.78 ppm
65 5.29 ton/ac	#87 (#2 ranked) 55	87 46.17 ppm	41 5.57 ppm
66 3.48 ton/ac	#40 (#3 ranked) 54	108 30.58 ppm	87 10.92 ppm
86 3.58 ton/ac	#391 (#4 ranked) 54	130 25.39 ppm	108 7.15 ppm
87 3.46 ton/ac	#387 (#5 ranked) 52	259 26.86 ppm	130 5.89 ppm
130 6.35 ton/ac		279 28.95 ppm	257 5.73 ppm
131 3.57 ton/ac		286 31.34 ppm	259 5.55 ppm
150 3.25 ton/ac	** Adjusted Rank	287 52.19 ppm	279 6.35 ppm
169 5.02 ton/ac	#332 (#1 ranked) 61	309 34.22 ppm	286 6.47 ppm
188 3.34 ton/ac	# 92 (#2 ranked) 42	335 105.75 ppm	287 9.81 ppm
250 4.34 ton/ac	#387 (#3 ranked) 42		309 7.53 ppm
256 4.34 ton/ac	#322 (#4 ranked) 38		335 22.81 ppm
261 3.25 ton/ac	#385 (#5 ranked) 36		
280 3.34 ton/ac			
296 3.53 ton/ac			
297 4.84 ton/ac			
298 4.02 ton/ac			
336 3.10 ton/ac			
351 3.25 ton/ac			
371 4.45 ton/ac			
403 4.96 ton/ac			

** Rank adjusted for distance from stream or lake

Table 22. Critical Cells in Subwatersheds 2, 10 and 11

SUB WATERSHED 2 (150)

CELL	SEDIMENT (tons / acre)	NITROGEN (tons / acre)	PHOSPHORUS (tons / acre)
15	---------------	21.22	4.98
16	---------------	21.22	4.98
17	---------------	21.22	4.98
31	---------------	21.22	4.98
46	---------------	18.36	---------------
86	---------------	18.74	---------------

SUB WATERSHED 10 (201)

CELL	SEDIMENT (tons / acre)	NITROGEN (tons / acre)	PHOSPHORUS (tons / acre)
201	2.84	---------------	---------------
203	---------------	21.22	4.98
226	---------------	21.22	4.98
230	2.84	---------------	---------------
256	4.34	---------------	---------------
257	---------------	24.65	5.73
280	3.34	---------------	---------------
284	2.84	---------------	---------------
311	---------------	18.93	---------------
313	2.13	21.22	4.98
315	2.84	---------------	---------------
332	---------------	19.67	---------------
335	---------------	105.75	22.81
336	3.10	---------------	---------------
350	2.20	---------------	---------------
351	3.25	---------------	---------------
366	2.84	---------------	---------------
367	---------------	21.22	4.98
368	2.50	---------------	---------------
369	2.13	21.22	4.98
381	---------------	21.22	4.98

SUB WATERSHED 11 (162)

CELL	SEDIMENT (tons / acre)	NITROGEN (tons / acre)	PHOSPHORUS (tons / acre)
182	2.19	---------------	---------------
208	2.84	---------------	---------------
259	2.84	---------------	---------------
260	2.84	---------------	---------------
316	2.13	---------------	---------------

An analysis of the Pelican Lake watershed indicates that there are approximately 21 cells which have greater than 3.0 tons/ acre of sediment yield. This is approximately 6% of the cells found within the watershed. The model estimated that there are 10 cells which have nitrogen yields of >25 ppm and 12 cells which have phosphorus yields >5.0 ppm. This is approximately 2.5% of the cells within the watershed. The location and yields for each of these cells are listed in APPENDIX B. pp. B69-B71. These cells should be given high priority when installing any future Best Management Practices (BMP's). The model also indicated that subwatersheds 10, 11 and 2 have the largest sediment/ nutrient per acre loadings. Therefore BMP's should be concentrated in these three subwatersheds. The cells listed on the preceding page and detailed in Appendix B., pp. B76-B87, should be targeted for the implementation of appropriate BMP's.

OBJECTIVE 3 - FEEDLOT RANKINGS (25 YEAR EVENT)

Table 23. Identification of Critical Feedlots

Feedlot Cell #	Subwatershed Location	AGNPS Rating (25Yr.EVT)	Ranking Priority	Variance from Mean of 33.7	Variance from 1 STD. Dev. (σ=19.1) from Mean	Priority Rank and C.Factor	Rank Based Distance C. Rate	On AGNPS Factors * C. Rank
9	4	15	17	- 18.7	- 0.98	.80	12	16
22	4	31	11	- 2.7	- 0.14	.90	28	10
40	5	54	3	+ 20.3	+ 1.06	.54	29	9
87	3	55	2	+ 21.3	+ 1.11	.54	30	8
92	4	42	7	+ 8.3	+ 0.43	1.00	42	2
205	11	0	20	- 33.1	- 1.76	.72	0	20
208	11	14	18	- 19.7	- 1.03	.54	8	19
238	12	13	19	- 20.7	- 1.08	.80	10	18
240	DIRECT	22	13	- 11.7	- 0.61	1.00	22	12
257	10	18	16	- 15.7	- 0.82	.80	14	14
283	10	39	9	+ 5.3	+ 0.28	..80	31	7
287	11	21	14	- 12.7	- 0.66	.64	13	15
309	9	39	10	+ 5.3	+ 0.28	.90	35	6
322	7	42	8	+ 8.3	+ 0.43	.90	38	4
332	10	76	1	+ 42.3	+ 2.21	.80	61	1
335	10	22	12	- 11.7	- 0.61	.80	18	13
385	7	45	6	+ 11.3	+ 0.59	.80	36	5
387	7	52	5	+ 18.3	+ 0.96	.80	42	3
391	8	54	4	+ 20.3	+1.01	.48	26	11
417	7	20	15	-13.7	- 0.72	.56	11	17

* Priority Rank = AGNPS 25 Year Feedlot Rating X Distance From Stream X Distance To Lake

<u>Distance To Stream Factors</u>

Adjacent to stream		= 1.0
Within 1 cell	(1,300 feet)	= 0.8
Within 2 cells	(2,600 feet)	=0.6
Within 3 cells	(3,900 feet)	=0.4
Within 4 cells	(5,200 feet)	=0.2

Mean value = 25.3
Median Value = 27.0
STDS = 14.8
Mean + 1STDS = 40.1

<u>Distance To Lake Factors</u>

Adjacent to lake		= 1.0
Within 4 cells	(5,200 feet)	= 0.9
Within 8 cells	(10,400 feet)	= 0.8
Within 16 cells	(15,600 feet)	=0.7
Within 20 cells	(20,800 feet)	=0.6

Table 24. Feedlot Selection Criteria and Statistics (Not Weighted for Distance Factors)

1.)	Animal Feedlot ranking	25 year event
2.)	Range of feedlot rankings	0 - 76
3.)	Mean	33.7
4.)	Sample standard deviation	19.1
5.)	Feedlots with rating $\geq +1\ \sigma$ are:	Cell 40, 87, 332, 387, 391

Cell # 40	
Nitrogen concentration (ppm)	11.097
Phosphorus concentration (ppm)	3.994
COD concentration (ppm)	170.814
Nitrogen Mass (lbs.)	312.718
Phosphorus Mass (lbs.)	112.552
COD Mass (lbs.)	4,813.609
Animal feedlot ranking number	54 ($+1.06\sigma$)

Cell # 87	
Nitrogen concentration (ppm)	10.107
Phosphorus concentration (ppm)	2.450
COD concentration (ppm)	91.668
Nitrogen Mass (lbs.)	795.940
Phosphorus Mass (lbs.)	192.939
COD Mass (lbs.)	7,219.232
Animal feedlot ranking number	55 ($+1.11\sigma$)

Cell # 332	
Nitrogen concentration (ppm)	10.106
Phosphorus concentration (ppm)	2.216
COD concentration (ppm)	92.273
Nitrogen Mass (lbs.)	2,554.387
Phosphorus Mass (lbs.)	560.050
COD Mass (lbs.)	23,322.640
Animal feedlot ranking number	76 ($+2.21\sigma$)

Table 24. Continued

Cell # 387	
Nitrogen concentration (ppm)	6.801
Phosphorus concentration (ppm)	2.153
COD concentration (ppm)	82.053
Nitrogen Mass (lbs.)	365.116
Phosphorus Mass (lbs.)	115.578
COD Mass (lbs.)	4,404.751
Animal feedlot ranking number	52 (+0.96σ)

Cell # 391	
Nitrogen concentration (ppm)	11.858
Phosphorus concentration (ppm)	3.967
COD concentration (ppm)	170.733
Nitrogen Mass (lbs.)	333.121
Phosphorus Mass (lbs.)	111.451
COD Mass (lbs.)	4,796.490
Animal feedlot ranking number	54 (+1.06σ)

Feedlots located in cells 40, 87, 332, 387 and 391 appear to be contributing excessive nutrients to the watershed (>1σ), while all other feedlots in the watershed appear to have very little impact on nutrient loading. However, feedlots located in cells 92, 322 and 385 should also be considered due to their proximity to major streams and the lake. If nutrient contributions from these 8 feedlots were eliminated, the model estimated that the nitrogen and phosphorus loadings to Pelican Lake would respectively be reduced 17% (9.9 tons/ year, 25 year event) and 5% (0.9 tons/year, 25 year event). Another possible source of nutrient loading is from septic systems and from livestock depositing fecal material directly into the lake or adjacent streams. Overall, the nutrients being deposited from the watershed into Pelican Lake appear to be abnormally high.

Conclusions

Based on a comparison of other watersheds in eastern South Dakota, the sediment and nutrient loadings to Pelican Lake appear to be high. This can partially be explained by the fact that the transport distances from a pollutant source to the lake are fairly short. However, when a subwatershed analysis is performed, above normal (> +1σ) sediment loadings were found in subwatersheds 10 (14% watershed area, 30% sediment) and 11 (7% watershed area, 13% sediment), and high nutrient loadings were found in subwatersheds 2 (5% watershed area, 10% nitrogen, 9% phosphorus, 0 feedlots) and 10 (14% watershed area, 20% nitrogen, 22% phosphorus, 4 feedlots). The implementation of appropriate BMP's targeted to critical watersheds 10, 11 and 2 and critical feedlots should produce the most cost-effective treatment plan in reducing sediment and nutrient loadings to Pelican Lake.

SEPTIC SYSTEM SURVEY

A survey of septic wastewater disposal systems was conducted at Pelican Lake by members of the Lake Pelican Association and project staff. A total of 22 of 40 survey reports were returned for Pelican Lake. Of the 22 reports, 16 (72%) had documented dates for construction of the septic systems. In checking the construction dates, it was found that of the 16 reported dates, 9 (56%) were older than 1980. A total of 5 (31%) were constructed between 1980 and 1990, and 2 systems (13%) had been installed since 1990. Overall, the results of the survey indicate that 81% of the reported septic systems are ten years old or older.

Of the 22 total septic system reports that were obtained, 15 (68%) had the distance from the system drainfield to the lake documented. Of the 15 reports with documented distances, 4 indicated a distance of less than 100 feet from the drainfield to the lake. This would indicate that approximately 27% of the reported systems have a distance of less than 100 feet between a drainfield and the lake. The minimum distance required between a drainfield and a lake, under current state rules, is 100 feet (Annotated Rules of South Dakota, Chapter 74:03:01, Individual and Small On-Site Wastewater Systems). Based on the results of the survey, it is estimated that about 27% of the existing wastewater septic systems around Pelican Lake have drainfields that would not meet present construction standards.

Given the age and location of many of the septic systems around the lake, it can be assumed that a significant number of these systems are causing a direct impairment of water quality. Measures should be taken to eliminate these direct sources of contamination to the lake.

SHORELINE EROSION SURVEY

A survey of the Pelican Lake shoreline was conducted on September 28, 1993. A pontoon was used to survey the entire shoreline around the lake. Areas of erosion were documented by photography and videotape. In addition, the areas of erosion were recorded on a map of Pelican Lake. For each area of erosion, an estimate was made of the height, length, and severity. The subjective categories chosen to categorize severity of erosion were as follows:

* Minor
* Intermediate
* Severe

A total of 4,330 feet (1,320 m) of the shoreline was found to have some degree of erosion. All of the areas in the Intermediate and Severe erosion categories (3,330 feet or 1,015 m) represent the greatest potential loadings of sediment to Pelican Lake and should be corrected as soon as possible.

A summary of the height (H) and length (L), in feet, within each erosion category is found in Table 25.

Table 25. Pelican Lake Shoreline Erosion Survey, September 28, 1993

	Minor	Moderate	Severe
	H / L	H / L	H / L
	2 / 300	10 / 600	15 / 900
	3 / 150	15 / 400	13 / 300
	4 / 250	15 / 150	20 / 800
	5 / 200		18 / 200
			20 / 80
Avg. Height	3.5	13.3	17.5
Total Length	900	1,150	2,280
% of Total Shoreline (68,640 feet)	1.3%	1.7%	3.3%

Figure 68, on the following page illustrates the areas of Minor, Intermediate, and Severe erosion around the lake.

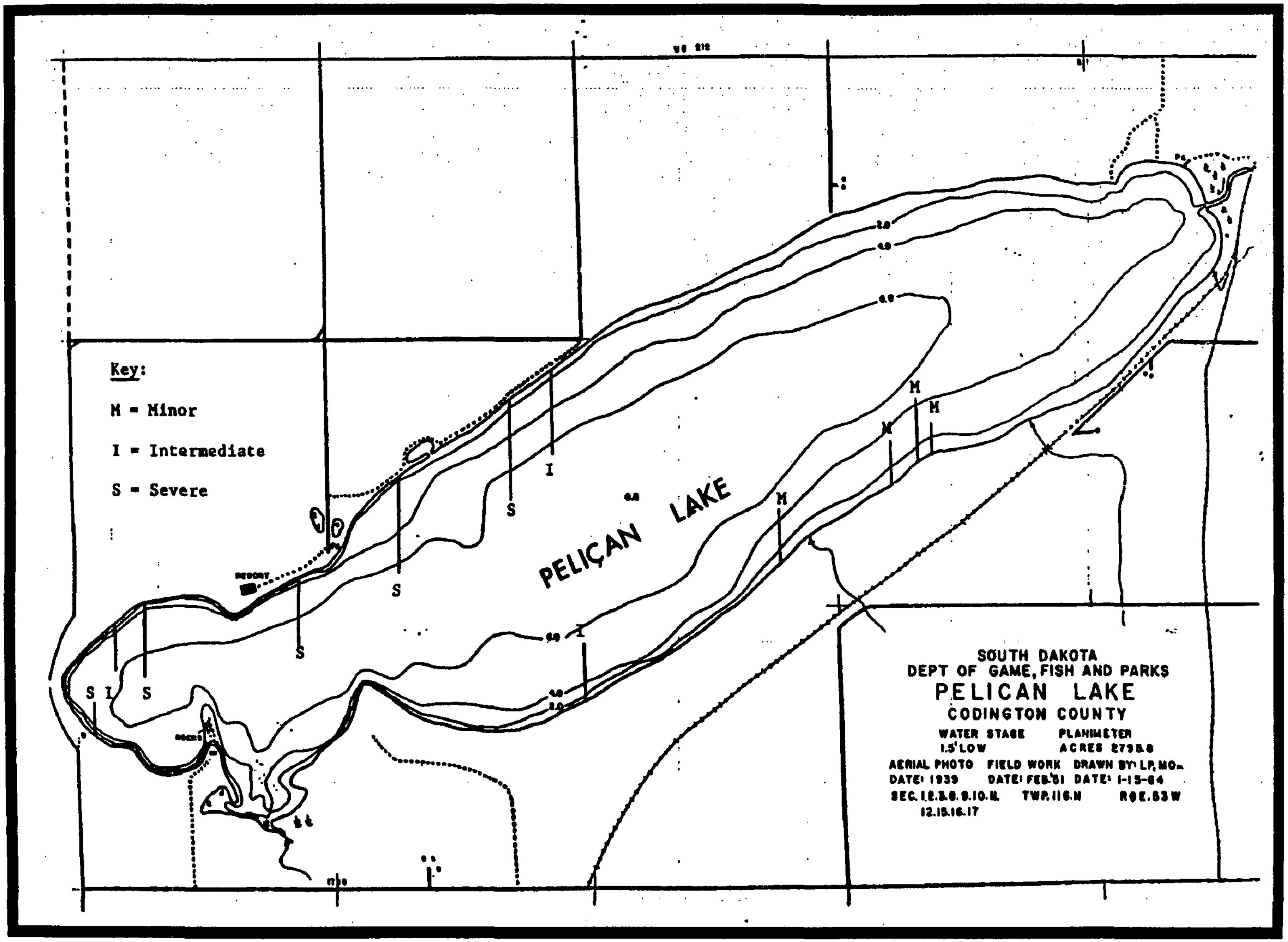


Figure 68. Pelican Lake Shoreline Erosion Map

On November 8, 1994, staff from the Natural Resources Conservation Service (NRCS) Midwest National Technical Center (MNTC) at Lincoln, Nebraska, made a site visit to Pelican Lake to assess shoreline erosion and potential corrective measures. The MNTC staff inspected shoreline erosion areas on private and public land, and sent a trip report with recommendations:

RECOMMENDATIONS (PRIVATE HOMEOWNERS)

1. A more detailed analysis of physical conditions, ecological functions and social values is needed to establish ecosystem objectives. Some analysis should also be made of having the spillway for the lake lowered to create a flatter runon area for a beach that would dissipate wave energy and greatly reduce shoreline erosion problems.

2. If hard point alternatives are going to be considered, detailed design parameters need to be developed. Existing treatments are failing due to lack of design. A more detailed physical site analysis is also needed that includes actual beach slope, wave height, bank soil type, foundation material, and existing vegetation.

3. It was suggested that homeowners may want to try a nontraditional approach to shoreline protection. We would encourage the use of any of the soil bioengineering or biotechnical approaches mentioned. However, we would suggest starting with small trials. These areas should be monitored for several years prior to large scale applications.

4. It is recommended that the landowners obtain technical design assistance . . . .

RECOMMENDATIONS (GAME, FISH AND PARKS)

1. It is recommended that the state consider working with homeowners, and others interested in lake use, to have the spillway lowered to create a flatter runon area for a beach that would dissipate wave energy and greatly reduce their present shoreline erosion problems.

2. It is recommended that the state consider obtaining technical assistance to design and construct a breakwater offshore from the high bank to reduce the erosion at the base of the bank due to wave action. As the steep bank continues to fail, the sloughed materials will be caught in the more quiet water between the existing shore and the breakwater. This area will eventually evolve to a drier, upland surface that grades into the toe of the existing bank as the high bank continues to erode to a stable configuration.

3. It is recommended that the state examine at least two alternative breakwater designs. One design involves piling rock in the water offshore and allowing the area behind the breakwater to naturally fill in as the high bank continues to slough during wet seasons. An alternate design would be to place fill from the toe of the existing bank out to the point of the breakwater and then place rock on the face of the fill at the new shoreline. The rock quantities in the two designs vary. Without the earth fill, much more rock will be required to establish a stable breakwater. The costs of less rock with earth fill versus more rock without earth fill should be compared.

WIND-WAVE ANALYSIS

A wind and wave analysis was performed by the Army Corps of Engineers in August, 1994, to evaluate flood control measures for Watertown and vicinity. The damage analysis in the study considers lake levels and wind-wave actions which cause damage to developments around both Pelican Lake and Lake Kampeska. High lake levels have had long durations which occurred in concert with strong winds on Lake Kampeska and Pelican Lake. Each lake has experienced damage caused by high winds that force waves up on the shore. Normally this has occurred when lake levels were already at high levels caused by Big Sioux River inflows. The high winds cause wave run-up, which creates greater lake depths along the receiving shorelines. Wind-wave action is dependent on wind direction and speed with regard to which areas of lake shoreline are affected.

The wind-wave analysis for Lake Kampeska and applied to Pelican Lake determined that the problems with wind-wave action begin to occur when the lake elevations reach about 1.2 feet above the normal full elevations. Wave run-up, being significant in height, is carried onto the lake shore, causing damage to developments. The wind causes lake run-up, which increases flood inundation depths on the receiving shoreline and causes a force which can severely damage property. The lakeshore damage caused by wind-wave action includes: loss of boat docks, landscaping plant material loss, shoreline structure displacement, and severe shoreline erosion.

METALS SAMPLING

In March, 1994, two samples of inflowing water from the Big Sioux River were collected at the Pelican Lake inlet/outlet and sent to the South Dakota Department of Health Laboratory at Pierre, SD, for metals analysis. The State Health Lab Metal Analysis Reports for March 17 and 18, 1994, are included as Figures 69 and 70.

The following are the acute and chronic surface water quality metal standards obtained from the Administrative Rules of South Dakota (ARSD, Chapter 74:03:02).

Table 26. Surface Water Quality Metal Standards

	Acute	Chronic
Arsenic	360ug/L	190 ug/L
Barium	1 mg/L	---
Cadmium	3.9 ug/L	1.1 ug/L
Chromium	16 ug/L	11 ug/L
Lead	82 ug/L	3.2 ug/L
Mercury	2.4 ug/L	0.012 ug/L
Selenium	20 ug/L	5 ug/L
Silver	4.1 ug/L	---
Sodium	No standards available	

Acute refers to a stimulus severe enough to rapidly induce an effect--in aquatic systems an effect observed in 96 hours or less. Chronic refers to a stimulus that lingers or continues for a relatively long period of time, often one-tenth of an organism's life span or more.

The metal levels found in Pelican Lake (Figures 69 and 70)are well below the acute and chronic surface water quality metal standards.

GREAT FACES. GREAT PLACES.

DEPARTMENT OF HEALTH

LABORATORY SERVICES
500 East Capitol Avenue
Pierre, South Dakota 57501-5093
(605) 773-3368 FAX: (605) 773-6129

Date: 11/3/94

Submitter copy to:

LAKE PELICAN WATERSHED DISTRICT-5220
ALVIN'S MUSIC
10 EAST KEMP
WATERTOWN, SD 57201

Spec #: E94IN003509
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source
PELICAN LAKE

Date Rcvd: 3/21/94
Time Rcvd: 0800
Date Coll: 3/17/94
Time Coll: 1230

County: CODINGTON
Spec Type: WATER
Coll By: MADISON/BUBLITZ/HAAG

Final Results

Arsenic	2.7 ug/L
Barium	<150 ug/L
Cadmium	<0.47 ug/L
Lead	0.7 ug/L
Mercury, Total	<0.2 ug/L
Selenium	0.6 ug/L
Silver	<0.16 ug/L
Chromium	<1.6 ug/L
Sodium	6.9 mg/L

Specimen Comments:
NOT PRESERVED PRIOR TO SHIPPING. STAFF GAGE = 10.74.
FLOW INTO LAKE STARTED DAY BEFORE (3-16-94)

Figure 69. State Health Lab Analysis Report Sheet March 17, 1994

South Dakota

GREAT FACES. GREAT PLACES.

DEPARTMENT OF HEALTH

LABORATORY SERVICES
500 East Capitol Avenue
Pierre, South Dakota 57501-5093
(605) 773-3368 FAX: (605) 773-6129

* Page 1 of 1 *
Date: 11/3/94

Submitter copy to:

LAKE PELICAN WATERSHED DISTRICT-5228
ALVIN'S MUSIC
10 EAST KEMP
WATERTOWN, SD 57201

Spec #: E94IN003520
Subm #:
Lab: ENV CHEMISTRY
Tel #: (605)773-3368

Source

PELICAN LAKE

Date Rcvd:	3/21/94	County:	CODINGTON
Time Rcvd:	0000	Spec Type:	WATER
Date Coll:	3/18/94	Coll By:	MADISON/DUBLITZ/HAAG
Time Coll:	1130		

Final Results

Arsenic	2.0 ug/L
Barium	<150 ug/L
Cadmium	<0.47 ug/L
Chromium	<1.6 ug/L
Lead	0.9 ug/L
Mercury, Total	<0.2 ug/L
Selenium	0.2 ug/L
Silver	<0.16 ug/L
Sodium	6.7 mg/L

Specimen Comments:
NOT..PRESERVED.PRIOR..TO.SHIPPING....STAFF.GAGE.10.82..FLOW.INTO LAKE.

Figure 70. State Health Lab Analysis Report Sheet March 18, 1994

Phosphorus Reduction Model

The water quality goal for Pelican Lake is to change the lake from hypereutrophic to eutrophic. The mean in-lake total phosphorus concentration was 105 micrograms/liter during the assessment project. This represents a trophic state index (TSI) of 71.34 for total phosphorus. The total phosphorus concentration must be lowered to 70 micrograms/liter, a reduction of 44%, to achieve a eutrophic state with a TSI of 65.

These results are derived from the phosphorus reduction-response equations found in Wetzel, 1983, pages 289 to 294. These equations are used to estimate in-lake phosphorus reductions in response to the implementation of best management practices as outlined in the Pelican Lake AGNPS model report, 1994.

Equations used include the following:

Assuming steady-state conditions, the simple mass balance equation accounts for volumetric loading of phosphorus as well as losses by flushing and sedimentation [Vollenweider and Kerekes, 1980]:

$$\frac{d[\bar{P}]_\lambda}{dt} = \left(\frac{1}{\bar{\tau}_w}\right)[\bar{P}]_i - \left(\frac{1}{\bar{\tau}_p}\right)[\bar{P}]_\lambda$$

where $[\bar{P}]_\lambda$ = average (total) lake concentration (both dissolved and particulate phosphorus components)

$[\bar{P}]_i$ = average inflow concentration of total phosphorus

$\bar{\tau}_p$ = average residence time of phosphorus

$\bar{\tau}_w$ = average residence time of water

in which the right-hand terms represent the average rate of supply to and the average rate of loss of total phosphorus from the lake, respectively, and the left-hand term represents the corresponding temporal variations of the average lake concentration.

Then, simplifying Equation 2:

$$[\bar{P}]_\lambda = (\bar{\tau}_p/\bar{\tau}_w)[\bar{P}]_i$$

The premise of Equation 3 can also be expressed as

$$[\bar{P}]_\lambda = (1 - R)[\bar{P}]_i$$

where R = the phosphorus-retention coefficient:

$$R = \frac{[\bar{P}]_i - [\bar{P}]_\lambda}{[\bar{P}]_i} = 1 - \bar{\tau}_p/\bar{\tau}_w$$

or statistically approximately $\bar{\tau}_p/\bar{\tau}_w = \frac{1}{1+\sqrt{\bar{\tau}_w}}$ [Vollenweider, 1976; Larsen and Mercier, 1976]. An approximate retention coefficient as a function of hydraulic load (q_s) was found to be [Dillon, 1974; Kirchner and Dillon, 1975]:

$$R = 0.426\, e^{\text{[illegible]}} + 0.574\, e^{\text{[illegible]}}$$

where q_s = areal water load (hydraulic load) to the lake (m year^{-1}), calculated as the lake outflow volume divided by the lake surface area.

These two retention values, while not identical, yield similar results for lakes of mean depths between 10 and 30 m and hydraulic loads between 3 and 90 m year^{-1} [Vollenweider and Kerekes, 1980].

Wetzel, 1983

The profiles taken during the study period indicated that only limited stratification occurred in the lake. In-lake dissolved oxygen deficiencies do occur over large portions of the lake during both the summer and winter months. These deficiencies are enough to cause stress or death in the fish populations, but are of short enough duration that sediment phosphorus release should be minor in comparison to the surface water loadings. Therefore, a reduction of 44% of the total phosphorus loadings from the watershed should be adequate to reduce in-lake phosphorus concentrations from hypereutrophic to eutrophic levels.

BACKGROUND AND HISTORICAL INFORMATION

BRIEF HISTORY OF LAKE PELICAN AND SURROUNDING WATERSHED

Homestead Information:

Alexander and Sarah McIntyre and son William came to Dakota Territory in 1877 and inhabited a tree claim within the Pelican Lake watershed, two miles west of what is now Watertown. William became a prominent business man in Watertown building the first hotel in 1879, serving as mayor, and organizing the formation of Codington County. The McIntyre homestead is now owned by Gaylord Bohn.

Duane Richardson homesteaded in the Pelican Lake area in 1877 with sons LaRue and DeWitt who also established homesteads in the area. The Richardsons' homesteads are owned by Blanche Roso, Kenneth Lukonen, Roger and David McFarland, and Donna Zirbes.

In 1878, William C.Waite and wife Mary filed for homesteads in Pelican Township, Codington County. Six months later their son Milton also homesteaded in Pelican Township. Milton married Mary Bastinn in 1879, and their marriage license was the first issued in Watertown. William and Milton's homesteads are currently occupied by Lake City Dairy Inc. and Dale Jorgenson.

Alfred and Viola Briggs came to Pelican Township in 1881. They had five children. A grandson Alfred C. Briggs remained in the area and attended Pelican District 39 school. The original homestead is partially owned by Ralph Briggs and Roger Becking.

James and Margaret McCormick settled near Pelican Lake, and James was among the men who signed the petition forming Pelican Township in 1889. Clayton Barkley now owns the McCormick homestead.

Pelican School District 39, also known as the Zamow School, was organized in the early 1890's. The original school house was torn down and a new one built in 1925-26. The building is no longer standing on the original site. The district was reorganized into Watertown in 1967.

Housing Developments:

The housing development on Pelican Lake known as the Kittleson Addition is named after Cliff Kittleson, a trapper and dog trainer who lives in the area. The addition was known as The Dog House because people would drop their dog off at "the dog house" to be trained by Kittleson. The Kittleson Addition was developed in the 1960's.

The area known as East Air Haven was originally owned by the Krull family. The Krulls owned the quarter section bordering the lake from 1917 until they sold it in the mid 1960's.

Previous Condition of Pelican Lake:

The southeast half of Pelican Lake was full of rushes along the shoreline before the 1930's. The rushes provided habitat for young fish and also habitat for muskrats. In the 1930's there were ample perch, walleye, and northern pike in Pelican Lake. The trapping rate was also very high. Due to reduction in fish habitat, in 1934-1935 crushed car bodies were left on the ice to sink to the bottom of the lake with the spring thaw. The old car bodies were to provide a safe place for young fish to hide from predatory fish. A separate story indicates that the car bodies were placed in the lake to form the base for a road that was to be built from one side of the lake to the other.

Previous Projects, Research and Ideas:

Municipal annexation of Pelican Lake was considered in 1982. The annexation would have provided the lake residents with city gas, road maintenance, police and fire protection, electricity, water, and sewage but aalso would likely have caused an increase in residents' taxes. To determine the opinions of the residents on municipal annexation, a survey was taken of the persons in the proposed annexation area (including U.S. Highway 212, inside County Road 11, inside of the Township road one mile south of the lake, and inside County Road 17). The results indicated that the majority of Pelican Lake area residents who replied were against municipal annexation. Therefore, the annexation issue was not pursued any further.

The development of a sanitary district was also considered in 1982. A sanitary district would have provided a sewer system to serve the populated areas around the lake. After careful research, members of the Sanitary District Committee determined that a sanitary district would be the last avenue open to Pelican Lake because there was an extensive waiting list for funds (5-10 years), and because portions of the lake would not be involved in the sanitary district if there were rural water systems available in those areas.

The Lake Pelican Association considered installing aeration systems on Pelican Lake in 1982. Aeration systems alleviate low oxygen conditions in a lake bottom, and therefore help to prevent winter fish kills. Several companies were contacted and the Association explored the possibility of using either onshore blowers and submerged aeration devices or wind-powered lake circulators. Although there was strong interest initially, it was decided that the cost of the aeration devices and their subsequent operation were beyond the scope of the Lake Pelican Association's abilities.

Development and Duties of the Lake Pelican Association and the Lake Pelican Water Project District:

The Lake Pelican Association was formed in May of 1982. The purpose of the association is to provide Lake Pelican residents/property owners with an organization to represent them in matters affecting the lake. A Board of Directors and officers for the association were elected and meeting times were established. The Association sends out newsletters to inform area residents of current projects, fundraisers, meetings, and social events at Pelican Lake. The newsletter encourages the land owners to be involved with the lake and to support the Lake Pelican Association.

The Lake Pelican Water Project District was formed in 1988. The intent of the district is to sponsor small, local water projects that are not authorized by other types of districts such as irrigation districts and sanitary districts. The water project district is an indication of local support for lake preservation, and may make it easier for Pelican Lake property owners to compete for limited state and federal funds to implement improvements at the lake.

Pelican Lake Social Functions and Fundraisers:

The Lake Pelican Association has periodically held fundraisers to raise money for various lake projects and improvements. In the past it has sponsored fish feeds, dances, ice fishing derbies, carp fishing contests, spring fishing tournaments, boat trailer and boat motor raffles, and "Dunk the Klunk" raffles. The residents of Pelican Lake have had summer picnics and Christmas parties, among other social functions.

DESCRIPTION OF PUBLIC ACCESS

RECREATION AND PUBLIC ACCESS

Pelican Lake has a total shoreline length of 12 miles (19.3 km). Of this total length, almost half (5.6 miles) is publicly owned.** The publicly owned shoreline areas are managed by the South Dakota Department of Game, Fish and Parks and the City of Watertown (Figure 71). The 5.6 miles (9.0 km) of public shoreline are divided into the following access areas.**

Table 27. Pelican Lake Public Access.

Publicly owned lands	5.6 miles
Pelican Recreation Area	3.4 miles
N.W. Pelican Lakeside Use Area	1.4 miles
Outlet Area	0.2 miles
Railroad Track Area (south)	0.6 miles

** Four additional public section line accesses are located on the lake. One is on the north side of the lake (Pelican Township, Sections 2 and 3). Another is on the south side of the lake (Pelican Township, Sections 10 and 11). The third is located in the Polz Addition, Section 17, Lot 4. The fourth section line access is located in Section 2 between Lots 16 and 17.

For the 5.6 miles of publicly owned lands, there is existing public access to one-half (2.8 miles) of the shoreline. The following is a breakdown of the public areas with access to the shoreline.

Existing public access to shoreline		2.8 miles
Pelican Recreation Area		0.8 miles
Main Road	2,400 ft. / .45 mi.	
Thompson's Pt.	1,400 ft. / .27 mi.	
Primitive Trail	300 ft. / .06 mi.	
N.W. Pelican Lakeside Use Area		1.2 miles
Outlet Area (city and state land)		0.2 miles
Railroad Track Area		0.4 miles
Access Along Highway On West		0.2 miles

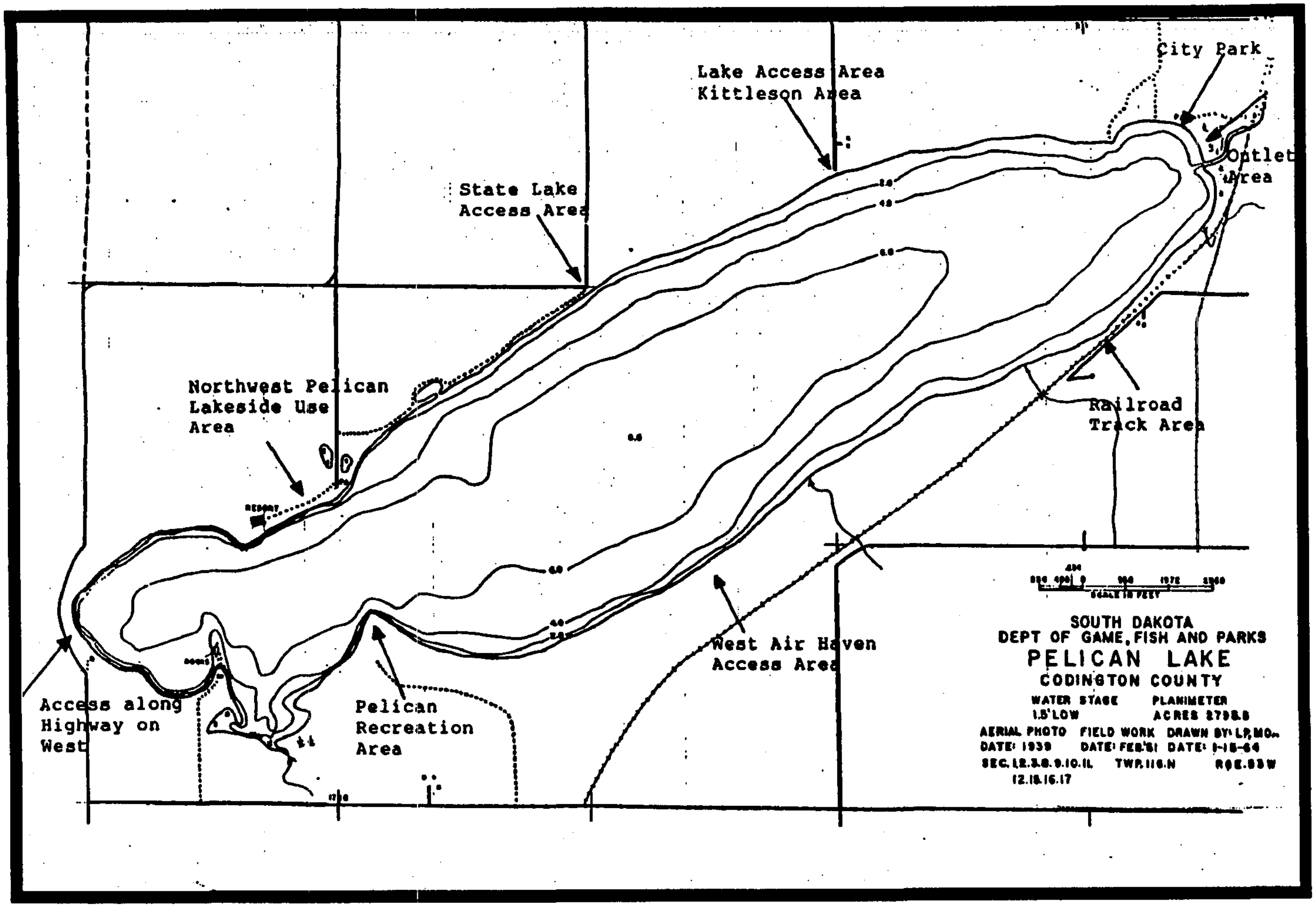


Figure 71. Pelican Lake Access Area Map

THE PELICAN LAKE RECREATION AREA**

*** The following is an excerpt from the SD Game, Fish and Parks Pelican Lake Recreation Area Master Plan, Preliminary Draft Master Plan, July, 1988.*

Management Zones and Developments

Recreation Area Development: The objective of a Recreation Area is to provide South Dakota residents and non-residents alike with the greatest number of high quality outdoor recreation opportunities that are consistent with the land use standards for state recreation areas. Keeping this in mind, the intensely developed portion of land in state recreation areas should comprise no more than one-half of the total land area. The undeveloped portion of lands will allow space for open areas, tree plantings, landscaping, trails, and wildlife found in the area.

Management Zones: Zones for various recreation activities, land uses, and open spaces have been established for the Pelican Recreation Area as a guide to park management. The zones include (1) Thompson's Point Lakeside Use Area / Fishing Access, (2) Day Use, (3) Overnight Camping, (4) Group Use, (5) Environmental Enhancement, and (6) Dispersed Use (Figure 72).

(1) Thompson's Point Lakeside Use Area/Fishing Access Zone management should primarily enhance shore fishing activity. To further justify sport fishing improvements, this point area would be reclassified as a Lakeside Use Area from its previous designation as part of Pelican Lake Recreation Area. Mowing of grass and tree trimming would be carried out as needed to facilitate this activity. An upgraded gravel road with new parking lots would be provided to improve access within this zone. Facility development might include an accessible fishing pier and other facilities which are normally provided at Lakeside Use Areas. An entrance fee would not be charged in this zone.

(2) The day use zone includes the facilities and activity areas for concentrated use such as those provided for picnicking, boating, swimming, and playgrounds. Mowing of grass and tree trimming would be carried out on a regular schedule. Toilets and drinking water should be available at convenient locations within this zone. Roads and parking lots would normally be hard surfaced when day use visitation approaches 50,000 visits per year. Other facilities which may be provided in the day use zone include picnic shelters, boat ramps, docks, bathhouses, and playground equipment.

(3) The overnight camping zone specifically provides facilities for visitors who wish to remain in the area overnight. Mowing of grass and tree trimming would be carried out on a scheduled basis to facilitate camping activity. The density of camping units should be from four to five units per acre. A unit consists of a parking space for camping vehicles, tent space, picnic table, and fireplace. Sanitary facilities (garbage and toilets) and drinking water should be available in the campground. Picnic table shelters should be provided at camping units where shade trees are not available. Some plant screening is desirable between camping units. The primary road within large campgrounds should be hard surfaced to eliminate the dust problem. Camping fees will be based upon the toilets and other services provided. Higher fees are required for a modern comfort station with shower. An additional $2.00 fee is charged for electrical service if it is provided.

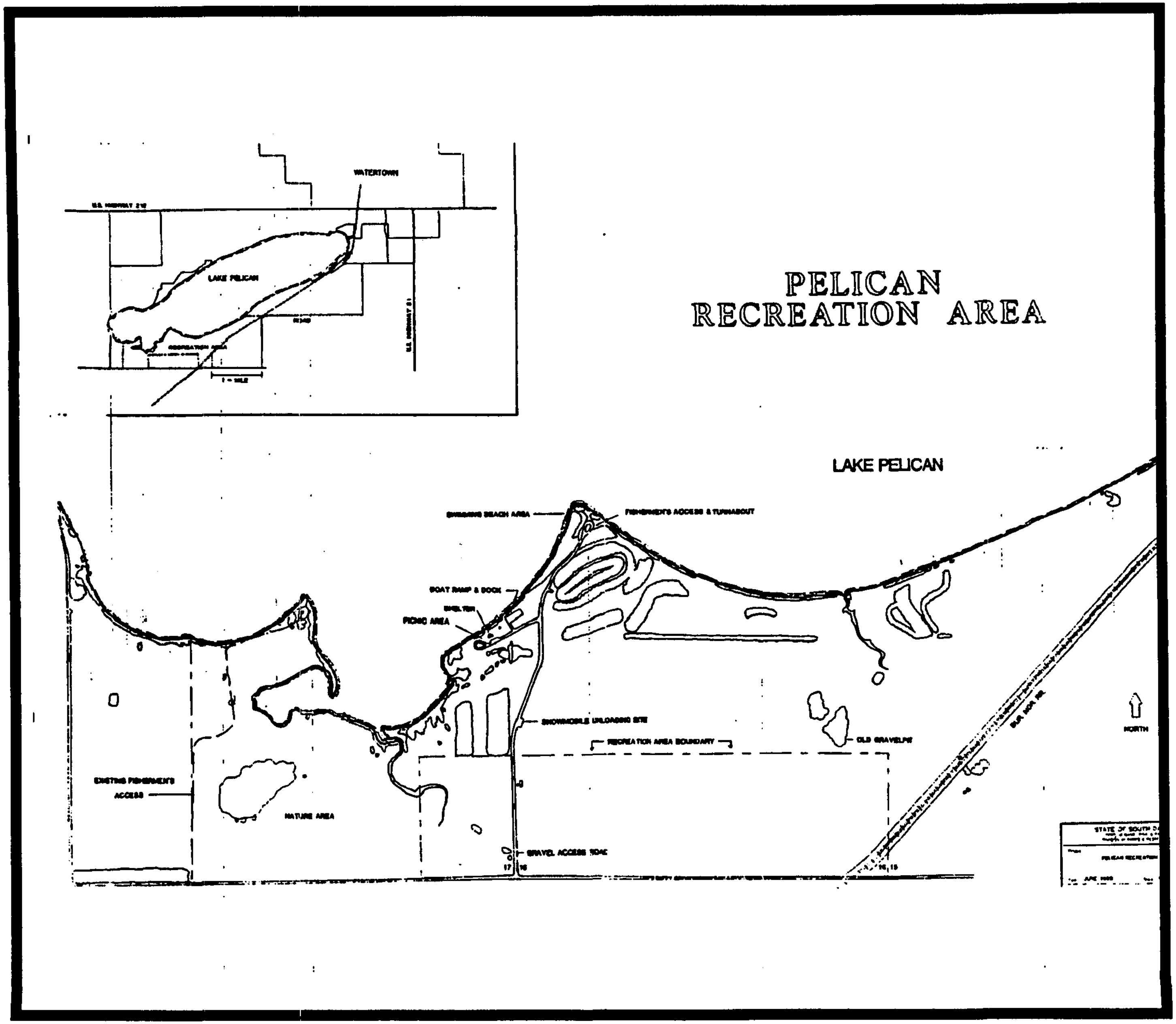


Figure 72. Pelican Lake Recreation Area Management Zones.

(4) A group use zone provides a site and facilities for groups such as scouts, 4-H, church groups or others to use within the recreation area. The group site at the Pelican Recreation Area may be reserved for day use activity or overnight camping. Facilities which may be provided include toilets, drinking water, picnic tables, fireplaces, playground equipment, game courts, and shelters. Fees may be charged for reservation services and overnight camping.

(5) The environmental enhancement zone will provide a large block of land where vegetative improvements will be made for the benefit of wildlife. Interpretive services (Jr. Ranger program, etc.) will be a major activity within this zone. Trail development, photo blinds, and observation towers would be the only recreation facilities provided. Trail development would also benefit walk-in fishing activity in addition to hiking and nature walks. Cross country ski trails will also be marked and/or groomed in winter months. Mowing of grass would be limited to trail corridors or where needed to control weeds. Tree trimming and removal of dead trees should not be done in this zone, except where needed for safety reasons along trails. No motorized vehicles will be allowed in the environmental enhancement zone. Hunting during regular seasons would be allowed.

(6) The dispersed use zone should be devoted primarily to multi-purpose trail use, walk-in fishing, and hunting activity. Vegetative management practices such as native grass seeding, controlled burns, tree plantings, and nesting cover plantings will be used to enhance trail use and wildlife production. Mowing of grass will be limited to trail corridors or where needed to control weeds. Motorized vehicle use will be limited to snowmobiles within this zone. Hunting during regular seasons would be allowed.

Shoreline Stabilization/Bank Erosion Control

Some of the shoreline along the Pelican Recreation Area is currently eroding into the lake or poses a threat in this regard. Because of this, areas of shoreline need to be stabilized, controlling bank erosion. Much of this same eroding shoreline has also formed high cutbanks. This not only hurts the quality of the lake , but also limits access to the shoreline, especially with respect to fishermen. A new Lake Restoration Plan for Pelican Lake is needed in order for the Department of Water and Natural Resources [Department of Environment and Natural Resources] to take action on this lake project. Formation of a Pelican Lake Water Project District will expedite and assist in development of this plan. Currently, there has been no organized effort to control the bank erosion, including that which is occurring within the recreation area. Development of the new Lake Restoration Plan will require a lot of time and planning before any real action can take place with respect to stabilization efforts.

Preliminary estimates on what it would cost to stabilize the shoreline run from $15 to $125 per linear foot of shoreline with an average cost being $60 per linear foot.

Because of the high cost associated with this type of project, priority ratings have been placed on specific shoreline areas in order that shoreline stabilization efforts can be spread out over time to balance out with the monies that will be needed to fund such an effort. These priority ratings reflect where bank erosion is threatening park facilities and overall water quality. A map has been used to indicate the priority areas and to derive preliminary cost estimates. Further assistance from the Department of Water and Natural Resources [Department of Environment and Natural Resources] will be needed in order to identify methods of controlling the bank erosion. In addition to this assistance, cooperation between the GF& P, DWNR [DENR], lake residents and the Pelican Lake Water Project District will all need to take place in order to prepare the overall plan and seek out the funding necessary to support such a large-scale project.

Recreation Development

Intensive Use Area

Recreational development is directly related to the level of use an area receives, but it also encourages more use. The Division of Parks and Recreation wants to be responsive to local needs and demands, but at the same time we want to be careful not to over-develop this area. With added development comes additional operating costs. The level of development proposed in this plan is similar to what we provide in other areas where an entrance fee is charged. As development proceeds, we will reach a point where a fee will be needed in order to recover costs.

Campground Area

Currently, the Department has scheduled a campground loop with fifteen pads to be built in addition to the 1990 DOT road surfacing project. These pads will be gravel-surfaced and be located in a deciduous tree-belt area overlooking Pelican Lake. The campground loop road will be hard surfaced to control dust from vehicle traffic. Pad dimensions would be 14 ft. (4.3m) wide and 65-70 ft. (18.3-21.3m) in length, which is the Department standard. Security lighting would be installed for the protection of overnight campers. The project does not include installation of electricity at any of the fifteen pad sites. However, installation of electrical pad pedestals could be added in the future as overnight camping increases in popularity.

Swim Beach Designation

Depth readings were taken along Goose Point to develop underwater contours which were studied in an effort to locate the best site for a swimming beach. A 200 ft. (161 m) length of shoreline beginning 250 ft. (76.2m)(approximately) south of Goose Point on the west side will be designated as the swimming beach area. The swim beach zone will extend out into the lake a distance of 200 ft. and be buoyed for swimmers' safety. This will keep boat traffic out of the area, and allow swimmers to enjoy a safe environment. Underwater contours indicate that the beach slope will be centered around a gradual 8% slope, which is a preferred slope for beach development. A dock or similar platform will be installed within the beach area to complement this facility. Adequate parking will also be provided for beach users.

Playground Facility Expansion
The present playground area consists of one swing set. With the campground and other development planned, playground facilities will need to be expanded. The original site will remain an excellent choice for expansion because of its day-use based activities. Two optional sites have been identified. One site would be located in the center of the proposed campground loop that would primarily serve the overnight park users. The other site would be located on Goose Point adjacent to the beach complementing this day-use facility.

Additional Land Acquisition
A 40-acre plot of privately owned land lies directly west of the main park entrance road. This plot, if acquired, would fill a void in our present park boundary. If it were managed by the Department, it would improve the visual impact of the entrance; provide land for hiking trail improvements; and the new land would improve organization of the park boundary.

Sport Fishing
Many of the issues surrounding Pelican Lake can be traced to the sport of fishing. Fishing is without a doubt the number one recreational pastime enjoyed presently by all ages at the Pelican Lake Recreation Area. Under this topic, many interrelated issues have been identified. Below is a list of these issues:

Boat Ramp Area
Presently, a 24 foot (7.3 m) wide boat ramp exists which consists of 12 foot (3.7 m)wide concrete plank sections placed side by side. This arrangement is marginal for launching two boats at the same time. The alternative will be to create a wider, double lane ramp by splitting the side by side 12 foot sections and placing the dock down the center. Labor costs will make up the majority of this project with new material costs being minimal since old plank could still be used. This will also be an excellent time to replace the worn sections of plank. For the convenience and safety of boat ramp users a sign will be placed on or near the ramp posting the area "off -limits" to swimming, diving, or fishing.

In conjunction with the 1990 road project, the boat ramp parking lot will also be expanded to increase the parking capacity. A striping plan will help organize parking and make better use of the available space. A parking lot capacity of 20 vehicles with boat trailers attached and approximately 10 parking spaces for "vehicles only" will be the goal of the expansion project.

Fishing Pier
Two sites have been evaluated and selected as good locations for fishing pier facilities. Both sites are currently heavily used fishing spots for shore fishermen and were selected on this basis. One site would be located approximately 400 feet (121.9 m) east of Goose Point. This site was chosen because of the popularity of fishing off this point and because of the limited shoreline fishing access available in this part of the park. The other site is on Thompson's Point where fishing is also very popular. Another positive aspect of the Thompson's Point site is the abundant natural underwater fisheries structure. At both sites, piers would be built to a length that would allow fishermen to cast into adequate depths. At least one of these facilities would also be made handicap accessible. Several

fishing pier designs are on the market today most of which would work. More research will be needed to select appropriate designs for these sites that will not only be functional, but also be aesthetically pleasing. The one at Thompson's Point would be permanent in nature and made of solid materials, while the one at Goose Point should be made of materials that will allow it to be removed annually.

<u>Fish Habitat Structure</u>
Thompson's Point and Thompson's Bay are the only two areas where any amount of naturally occurring fish structure is available with respect to the Pelican Lake Recreation Area. Fisheries biologists have suggested several locations where artificial fish structure could be placed to improve fishing and habitat quantities. Areas include Thompson's Bay and Goose Point. Several different types of man-made habitat structures are available, any of which are very inexpensive and do not require a lot of labor or maintenance (Figure 73).

<u>Walk-In Fishing Area</u>
Two sites have been selected as Walk-In Fishing Areas. These sites would allow fishermen to combine their favorite sport of fishing with hiking and give them a chance to get away from the crowds. The sites are located in Thompson's Bay and north of the old sand pits.

Both sites were chosen on their popularity, shoreline accessibility, and potential fishing expectation. The Thompson's Bay site already has an existing hiking trail that would provide access to this area.

<u>Exterior Roads</u>
The mile of gravel road between the paved county road on the west end of Pelican Lake and the entrance to Pelican Lake Recreation Area is usually quite rough. Upgrading this mile of gravel road to a hard surface will be explored in cooperation with township and county officials during 1990 in conjunction with scheduled interior road work. This will allow all the road work to be accomplished simultaneously and only tie the park up for part of one season.

It should be kept in mind that exterior road improvement cannot be accomplished without some form of cost-share and maintenance agreement with the township or county.

<u>Interior Roads</u>
Construction of a gravel campground road and fifteen camp pads has been budgeted for FY 1988. This "basic" type campground will be located in a tree planting just south of Goose Point. The entire recreation area gravel road system, including the campground road, is scheduled for upgrading to an asphalt surface during 1990. Along with this, construction of a ten

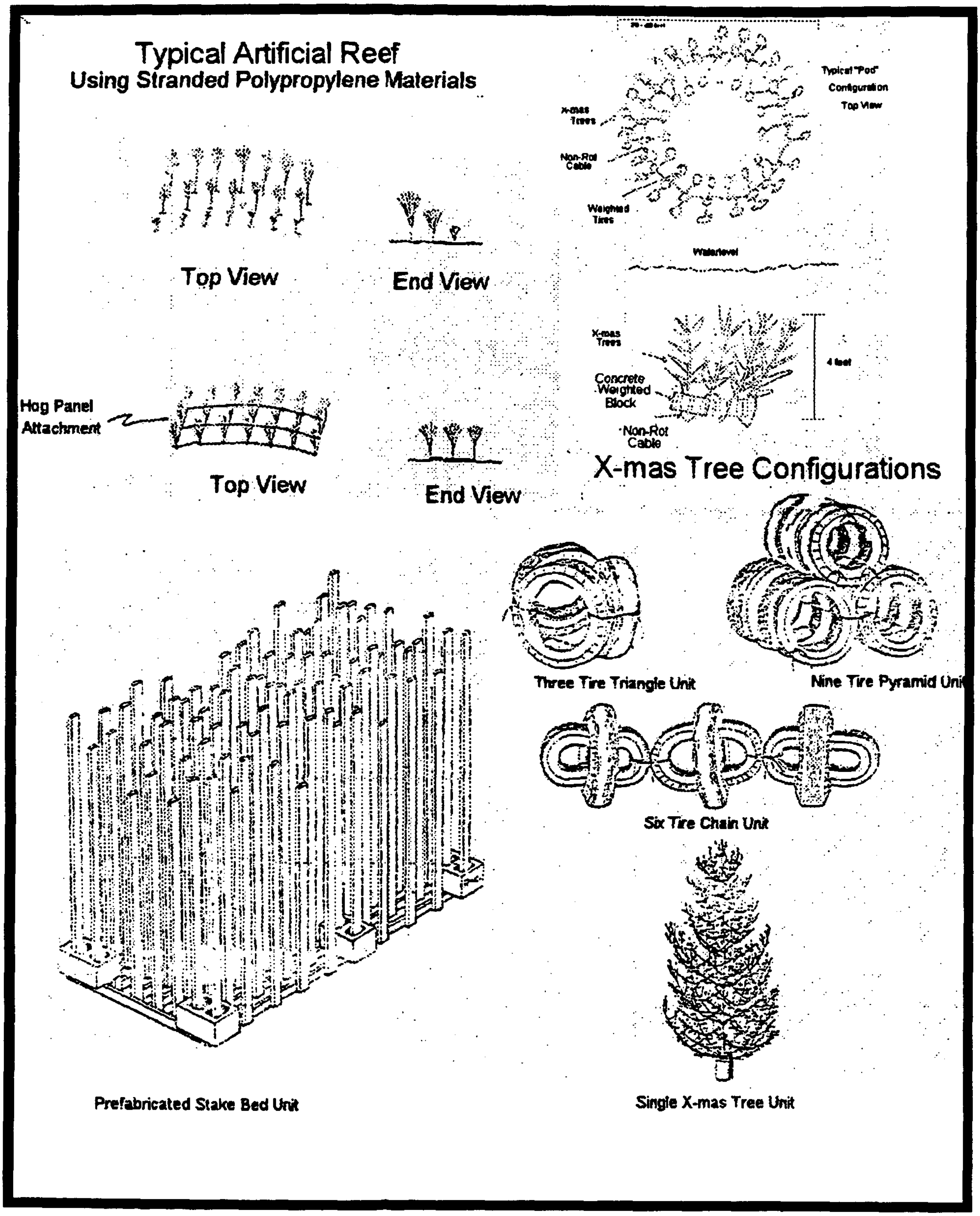


Figure 73. Fisheries Habitat Structure Diagrams

vehicle parking lot will take place adjacent to the Goose Point turn around. The parking area will allow excellent accessibility to the proposed fishing pier and other shore fishing. The picnic shelter parking lot will also need to be expanded to allow for the heavier use it is currently receiving.

In addition to the access provided to Pelican Recreation Area by the main entrance, two vehicle trails currently provide access to the shoreline during dry weather. The trail between Thompson's Point and the recreation area main road is about 0.3 miles (0.5 km) long and provides access to a little over 300 feet (91.4 m) of shoreline. Because of the limited access and shallow water depths in this location, the cost of road construction is not warranted. A parking lot should be constructed at the head of this trail to accommodate walk-in fishing and other recreational activities such as hunting. The other trail leading to Thompson's Point is 0.8 miles (1.3 km) long and provides access to 1400 feet (426.7 m) of shoreline. This trail will need to be upgraded to improve the overall road bed and make it useable in all weather conditions. Parking lots will be placed at several locations along this road where it is convenient for shore fishermen to find access to their favorite fishing spots. One of these parking lots would be constructed to provide access to walk-in fishing along 300 ft. (91.4 m) of shoreline on the south shore of Thompson's Bay. Constructing an all-weather road and parking lots could cost between $36,000 and $40,000. The 1400 feet (426.7 m) of shoreline on Thompson's Point is quite good for shore fishing because the shoreline banks are low and 4 ft. (1.2 m) water depths may be within casting distance.

Wildlife and Vegetation

Vegetative management practices and wildlife habitat improvements can be determined by use zones and soil suitability. The primary existing vegetative concern is the severe brome grass infestation.

The Thompson's Point area may be enhanced through tree belt plantings. Belts of at least 15 rows provide the greatest winter wildlife habitat benefit. A tree nursery would also serve a very functional purpose for the park and campground itself as well as a home for many wildlife species. Vegetation may also be enhanced by eliminating brome grass through cultivation and reseeding with areas of native grasses and dense nesting cover (alfalfa, sweet clover, and western wheat grass.) Food plots would also increase wildlife production in this area.

The area east of the main entrance road extending to the inlet is the only portion of the park with existing native vegetation. Native vegetation may also be increased through interseeding, chemical methods and cultivation. Additional tree plantings are also important.

The area from the inlet to the east property boundary is primarily brome grass. This area may best be cultivated and seeded to dense nesting cover while adding tree plantings and wildlife food plots. Chemical control of noxious weeds will also be necessary in some areas.

This issue is very complex and will require research in the areas of soil suitability, grass seed selection, tree site selection, and proper wildlife management. For this reason, a much more detailed vegetative management plan will need to be formulated than time presently allows for.
Snowmobiling will not be allowed west of the park entrance road in order to encourage wildlife to move into this area and use it as a refuge during the winter months.

Park Usage

The Pelican Lake Recreation Area has been a popular location for local and non-resident visitation and camping for many years. The Pelican Lake Recreation Area became a fee area October 1, 1991. This had a slight effect on the visitation to the park (Table 28). Recreation area improvements are being accomplished in a timely manner, which allows for a wide variety of activities at Pelican Lake.

Table 28. Pelican Lake Visitation 1979 to 1993.

YEAR	VISITATION
1979	6,905
1980	17,925
1981	42,203
1982	44,490
1983	41,828
1984	42,023
1985	52,341
1986	58,662
1987	60,265
1988	66,559
1989	59,299
1990	47,087
*1991	37,719
1992	33,905
1993	33,080

* Became a fee area October 1, 1991.

Other Lakeside Use area visitation numbers were unavailable, although usage of other areas is extensive.

COMPARISON OF LAKE USES TO USES OF OTHER LAKES IN REGION

Pelican Lake is larger than most of the lakes in the northeast region of South Dakota. Like most of the Prairie Coteau lakes, Pelican Lake was formed by glacial melting during the late Wisconsin Era, and is currently in a hypereutrophic condition.

The Prairie Coteau and surrounding region contain approximately two-thirds of all the lakes in South Dakota. Many of these lakes are shallow and eutrophic, so they do not support water-based recreation. Therefore, lakes in this region that provide recreational resources are extremely valuable. Table 29 lists all area lakes that support permanent recreational opportunities, and the municipalities nearest to the lakes. Pelican Lake has three parks, and four boat ramps. As can be seen from the list, this compares favorably with most of the other lakes in the region. Pelican Lake's parks support camping, picnicking, boating, fishing, and swimming. The recreational opportunities provided by Pelican Lake are vital to the City of Watertown, Codington County, and the surrounding region.

Table 29. Comparison of Pelican Lake to other Lakes Within an 80 km Radius

Lake	Parks	Ramps	Uses*	Nearest Municipality
Pelican Lake	**3**	**4**	**B,C,F,P,S**	**Watertown, SD**
Lake Hendricks	1	4	B,C,F,P,S	Hendricks, MN
Lake Kampeska	6	8	B,C,F,P,S	Watertown, SD
Whitewood Lake		2	B,F	Lake Preston, SD
Spirit Lake		1	B,F	Lake Norden, SD
Lake Albert		1	F	Lake Norden, SD
Lake Shaokatan		3	B,F,P,S	Ivanhoe, MN
Lake Thompson		2	B,F,P	Lake Preston, SD
Lake Sinai		1	B,F	Sinai, SD
Lake Preston			F	Lake Preston, SD
Lake Poinsett	1	6	B,C,F,P,S	Estelline, SD
Oak Lake			F	Astoria, SD
Oakwood Lakes	1	1	B,F,P,S	Bruce, SD
Lake Tetonkaha	1	2	B,C,F,P,S	Bruce, SD
Lake Cochrane	1	1	B,C,F,P,S	Gary, SD
Goldsmith Lake		1	B,F,S	Volga, SD
Lake Campbell	1	2	B,C,F,P,S	Brookings, SD
Lake St. John		1	B,F	Lake Norden, SD
Lake Norden	1	1	B,C,F,P,S	Lake Norden, SD
Willow Lake		1	B,F	Willow Lake, SD
Fish Lake		1	B,F,S	Astoria, SD
Clear Lake	1	1	B,C,F,P,S	Clear Lake, SD
Lake Alice		2	B,C,F,P,S	Altamont, SD
Round Lake		1	B,C,F,P,S	Goodwin, SD
Round Lake	1	1	B,F,S	South Shore, SD
Medicine Lake			C,P,S	Florence, SD
Rush Lake			B,F	Waubay, SD
Waubay Lake		1	B,C,F	Grenville, SD
Pickerel Lake	2	3	B,C,F,P,S	Grenville, SD
Enemy Swim Lake	1	2	B,C,F,P,S	Grenville, SD
Big Stone Lake	4	15	B,C,F,P,S	Ortonville, MN
Punished Woman's	1	2	B,C,F,P,S	South Shore, SD

* B=Boating, C=Camping, F=Fishing, P=Picnicking, S=Swimming

Source: South Dakota Game, Fish & Parks, Watertown Regional Office, 1993.

ECONOMIC AND USER POPULATION

SIZE AND ECONOMIC STRUCTURE OF POTENTIAL USER POPULATION

Pelican Lake lies just outside the City limits of Watertown, which is located in Codington County, South Dakota. In analyzing the size and economic structure of the potential user population for Pelican Lake, it is helpful to examine the characteristics of the City of Watertown, Codington County, and the surrounding area.

A study of the City of Watertown and its surrounding trade area was completed by the State Data Center Division of the Business Research Bureau, School of Business, University of South Dakota, Vermillion, South Dakota, in September, 1992 (Dykstra, 1992). The "Watertown Trade Area Capture Study" provides demographic profiles and economic characteristics for the City of Watertown, Codington County, and the area surrounding Pelican Lake.

Population Characteristics

South Dakota grew during the 1970's and continued to gain population during the decades of the eighty's and ninety's. However, that growth has been in pockets of the state. Only one in five of South Dakota's 66 counties grew between 1980 and 1990. Codington County was one of the growing areas in South Dakota during the 1980's with an 8.7 percent increase. The 1990 population of Codington County was 22,698, making it the fifth largest county in the State of South Dakota. The growth of Codington County during the 1980's was due to the population increase in the City of Watertown. Watertown grew at a rate of 12.4 percent between 1980 and 1990, giving it a 1990 population of 17,592. This ranks Watertown as the fourth largest City in the State of South Dakota.

Figure 74, shows the primary retail trade area for the City of Watertown. The estimated 1990 trade area population was 65,274. Although the trade area map is mainly used to give an indication of the retail area for the City of Watertown, it also gives a good indication of the potential user population for Pelican Lake.

As discussed earlier in this report, the recreational facilities at Pelican Lake compare very favorably to the facilities at other lakes in the region. It is assumed that the population within the Watertown trade area is probably willing to drive the same distance for excellent water-based recreational opportunities as they are for favorable retail trade opportunities. Therefore, the potential user population for Pelican Lake includes not only the populations of the fifth largest county and fourth largest city in the state, but also the Watertown trade area population of over 65,000 people.

Economic Characteristics

The economic characteristics of the potential user population for Pelican Lake are best portrayed by the socio-economic data from the 1990 Census for the City of Watertown. The number of persons in Watertown's labor force has increased by 19.5 percent from 7,506 in 1980 to 8,966 in 1990. This increase has resulted from more women and men entering the labor force. This differs from the South Dakota trend where the number of males in the labor force declined while the number of females increased for an overall labor force increase of 7.6 percent during the decade. The unemployment rate for Watertown during this same period dropped from 6.1 percent to 5.5 percent.

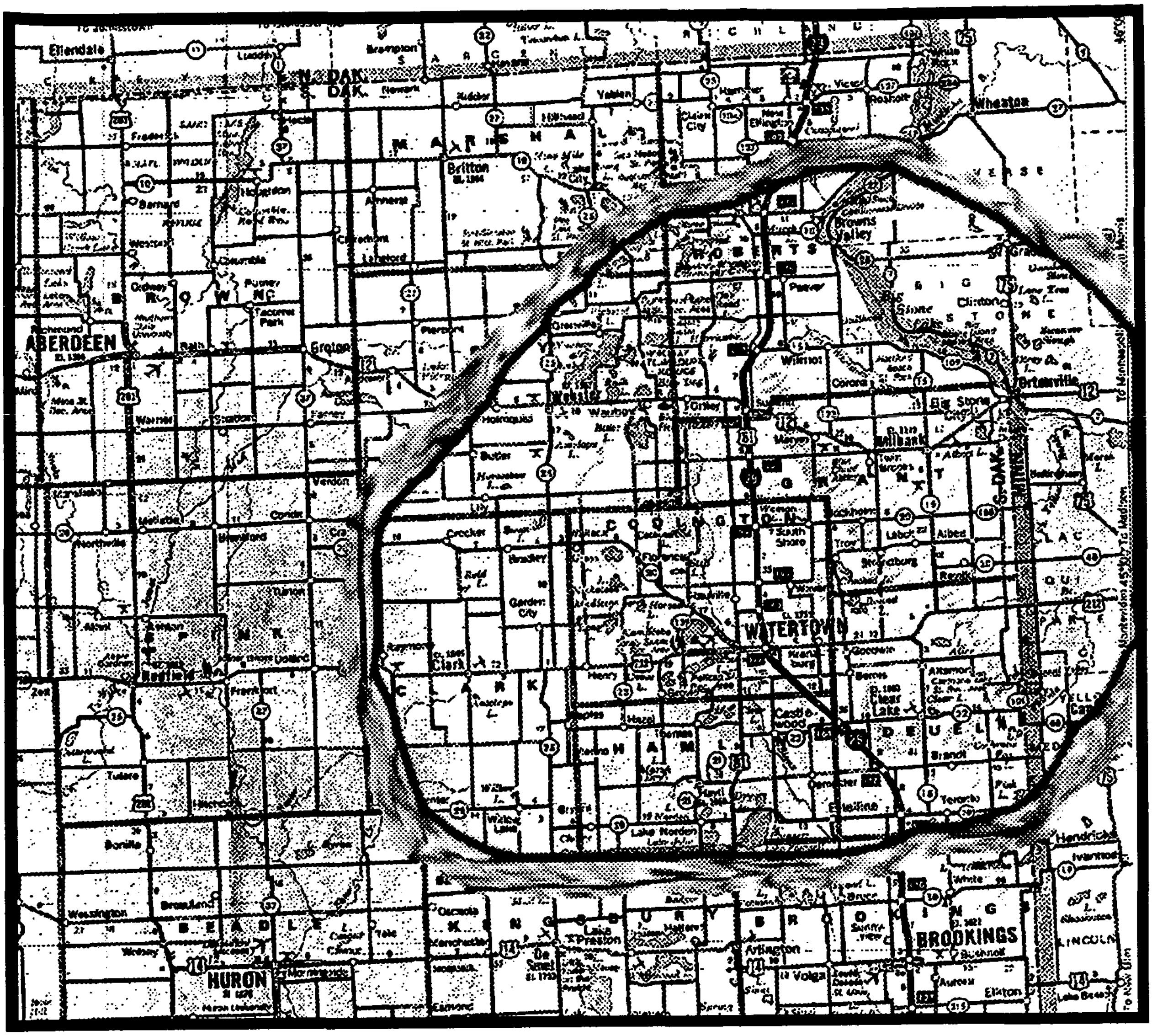


Figure 74. Watertown Trade Area Map

The most chosen jobs for Watertown residents are the sales occupations, with nearly as many occupied in the service occupations. However, the fastest growing job fields in Watertown are farming, forestry and fishing. This is in direct contrast to the South Dakota trend of a 22.6 percent drop in the farming, forestry and fishing occupations. It is probable that much of this growth in Watertown is due to semi-retired farmers moving into town or taking on a second job. This migration of semi-retired farmers into town would account for the growth of the farming occupation at Watertown.

Other areas of significant occupation for Watertown residents are the retail trade and durable goods manufacturing industries. Over thirty-six percent of the employed persons in Watertown (3,067 persons) work in these industries.

There is very little difference between Watertown and South Dakota with respect to income measurements. Watertown's per capita income of $10,660 in 1989 was nearly identical to the statewide per capita income of $10,661. Median household and family incomes for Watertown residents in 1989 were $20,606 and $27,602 respectively. These compare to 1989 median household and family incomes in South Dakota of $22,503 and $27,602 respectively.

Based on information published by the Business Research Bureau at the University of South Dakota, Vermillion, South Dakota (South Dakota State Data Center, Report SDC No. 94-103, 1994), it appears that the City of Watertown and Codington County will continue to grow substantially well into the next century. According to DeVee Dykstra, Director of the South Dakota Business Research Bureau, Watertown's rate of population growth will likely make it South Dakota's third largest city by the year 2000. An updated U. S. Census Bureau report shows that Watertown has increased 2.8 percent in population to 18,078 between 1990 and 1992, and continues to be one of the state's bright spots. The current third-largest city, Aberdeen, showed a modest increase of 0.1 percent to 24,953. "It will be awhile before they overtake Aberdeen, but at this rate, by the year 2000 that will happen," Dykstra stated in an article in the Sioux Falls Argus Leader newspaper (Sioux Falls Argus Leader, August 15, 1994).

Mainly because of the projected growth for Watertown, the county seat for Codington County, it is likewise anticipated that the county population will increase significantly. The State Data Center projections for Codington County indicate that the county population will increase from 22,698 in 1990 to 28,254 in the year 2015, which is a 25% increase (South Dakota State Data Center, Report SDC No. 94-101, 1994).

In summary, the demographic and economic characteristics of the potential user population for Pelican Lake indicate that the City of Watertown and the surrounding area is a thriving community that is continuing to expand and grow. The recreation and economic base provided by Pelican Lake has been, and will continue to be, a key factor in the continued success of this community.

POPULATION SEGMENTS ADVERSELY AFFECTED BY LAKE DEGRADATION

The population segments adversely affected by the degradation of water quality in Pelican Lake can be determined from the "Watertown Trade Area Capture Study" recently completed by the State Data Center Division of the Business Research Bureau, School of Business, University of South Dakota, Vermillion, SD (Dykstra, 1992). Presently, the City of Watertown is growing rapidly, with a 12.4 percent increase between 1980 and 1990. New businesses and industries are being attracted to the city, with associated growth in population and the housing industry. Much of this growth and expansion is directly attributed to the recreational opportunities provided by Pelican Lake. Therefore, a continued decline in water quality in Pelican Lake will have a definite adverse effect on the population of Watertown. In addition to the detrimental effect on the City of Watertown, the degradation of water quality in Pelican Lake would likewise have an adverse impact on the entire population of Codington County. The City of Watertown is the county seat, and the hub of industrial and retail trade activity. Continuing degradation in Pelican Lake's water quality would likely have an adverse effect on Watertown's economic well-being, and consequently the economic well-being of Codington County.

The "Watertown Trade Area Capture Study" indicates that the primary retail trade population for the City of Watertown was 65,274 in 1990. Pelican Lake's resources have contributed to the growth and expansion of Codington County, including its retail trade facilities. Consequently, a decline in the water quality of Pelican Lake would potentially have an adverse impact on a retail trade population exceeding 65,000 people.

SUMMARY AND CONCLUSIONS

Water Quality

The analysis of the tributary stream data from the current lake assessment project indicated that the water which flowed into Pelican Lake at Site PL-4 (Big Sioux River inlet) was the greatest source of loadings for all the chemical parameters analyzed. The majority of these loadings flowed into the lake immediately following snowmelt runoff. An evaluation of the monitoring results for the immediate watershed sites (PL-1, PL-2, and PL-3) indicated that the Site PL-3 (Foley Road) subwatershed contributed the greatest loadings of solids. The locations of the greatest nutrient loadings, on the other hand, appeared to vary. The greatest loadings of ammonia, TKN, total phosphorus, and total dissolved phosphorus flowed in from the Site PL-2 (Air Haven) subwatershed, while the greatest loadings of nitrate + nitrite originated in the Site PL-3 (Foley Road) subwatershed.

Comparison of tributary analysis and AGNPS summary

The Agricultural Nonpoint Source (AGNPS) computer runoff model indicated that the greatest suspended solids loadings would flow into Pelican Lake from the subwatersheds designated as subwatershed 10 and subwatershed 11. These subwatersheds correspond to the tributary stream subwatersheds which were monitored at Sites PL-2 and PL-3, respectively. The tributary monitoring indicated that the greatest suspended solids loadings occurred at Site PL-1.

The AGNPS model also indicated that subwatersheds 10 and 2 would be the sources of the greatest loadings of nutrients, both nitrogen and phosphorus. As discussed above, subwatershed 10 corresponded to the Site PL-2 subwatershed. The AGNPS subwatershed 2, however, which is located in the northeast corner of the immediate watershed, did not have a corresponding monitored site. The tributary monitoring confirmed that the Site PL-2 subwatershed was responsible for the greatest loadings of phosphorus and organic nitrogen, but indicated that the Site PL-3 subwatershed was the greatest source of inorganic nitrogen loadings.

Sedimentation

The preliminary results of the seismic sediment survey indicated that the total volume of fine-grained silty sediment in Pelican Lake was about 36 million cubic yards. The tributary monitoring indicated that approximately 147 cubic yards of additional sediment flow into the lake on an annual basis. This indicates a small amount of ongoing sedimentation. The results of the sediment survey bear witness to the vast accumulation of sediment in the lake.

Livestock Feeding Areas

The AGNPS runoff model was used to evaluate the confined feeding areas in the immediate Pelican Lake watershed. This evaluation was conducted for 20 feeding areas. There were three livestock feeding areas with existing ag waste systems which did not require an analysis using the AGNPS model.

Lake Shoreline

A survey of the Pelican Lake shoreline revealed that in spite of past efforts, there are still numerous areas of severe and moderate erosion. These areas of erosion are directly contributing to the ongoing sedimentation of the lake.

In-Lake Water Quality
The in-lake water quality monitoring program revealed that Pelican Lake is in a hypereutrophic condition. The monitoring also indicated that for most times of the year, the limiting nutrient for the lake has changed from nitrogen to phosphorus. Continued loadings of sediment and nutrients to the lake will contribute greatly to the ongoing eutrophication process.

Phosphorus Reduction Model
The water quality goal for Pelican Lake is to change the lake from hypereutrophic to eutrophic. The mean in-lake total phosphorus concentration was 105 micrograms/liter during the assessment project. This represents a trophic state index (TSI) of 71.34 for total phosphorus. The total phosphorus concentration must be lowered to 70 micrograms/liter, a reduction of 44%, to achieve a eutrophic state with a TSI of 65.

The profiles taken during the study period indicated that only limited stratification occurred in the lake. In-lake dissolved oxygen deficiencies do occur over large portions of the lake during both the summer and winter months. These deficiencies are enough to cause stress or death in the fish populations, but are of short enough duration that sediment phosphorus release should be minor in comparison to the surface water loadings. Therefore, a reduction of 44% of the total phosphorus loadings from the watershed tributaries should be adequate to reduce in-lake phosphorus concentrations to eutrophic levels.

Alternative #1 (Big Sioux River Diversion Control Structure) would for the most part exclude the phosphorus loadings from the Big Sioux River. Upon running the phosphorus reduction equation on the remaining immediate watershed tributary loads, it was found that a reduction of 41% of the phosphorus from the immediate watershed would attain the eutrophic levels desired. This reduction in the immediate watershed is possible through the BMP practices outlined in the AGNPS report (Appendix B). The installation of 8 animal waste systems would eliminate 5% of the phosphorus loads from the immediate watershed. The remaining 36% of phosphorus loads from the immediate watershed could be reduced with cropland based BMP's applied to critical cells outlined in the report. Sedimentation will be reduced in proportion to the reduction in erosion. Also the use of integrated crop management should reduce the amount of phosphorus and nitrogen per ton of sediment. The use of filter strips, riparian area improvement, and small dams will also help to reduce the delivery rate of sediment and phosphorus to the lake.

RESTORATION ALTERNATIVES

IMMEDIATE PELICAN LAKE WATERSHED AND IN-LAKE ALTERNATIVES

1) Big Sioux River Diversion Control Structure

Water flowing into Pelican Lake at Site PL-4 (Big Sioux River inlet) was identified as the greatest source of loadings of solids and nutrients. This indicates that the greatest amount of effort should be expended in trying to curb the inflow of contaminants from this source. Diverting this water or modifying the existing diversion structure in such a way as to decrease or stop these inflows should be considered as a supplement to the implementation of conservation practices in the Big Sioux River watershed. An engineering feasibility study should be conducted to determine the cost effectiveness of this alternative prior to any implementation strategy.

Alternative #1 (Big Sioux River Diversion Control Structure) would for the most part exclude the phosphorus loadings from the Big Sioux River. Upon running the phosphorus reduction equation on the remaining immediate watershed tributary loads, it was found that a reduction of 41% of the phosphorus from the immediate watershed would attain the desired trophic state. This reduction in the immediate watershed is possible through the BMP practices outlined in the AGNPS report (Appendix B). The installation of 8 animal waste systems would eliminate 5% of the phosphorus loads from the immediate watershed. The remaining 36% of phosphorus loads from the immediate watershed could be reduced with cropland based BMP's applied to critical cells outlined in the report. Sedimentation will be reduced in proportion to the reduction in erosion. Also the use of integrated crop management should reduce the amount of phosphorus and nitrogen per ton of sediment. The use of filter strips, riparian area improvement, and small dams will also help to reduce the delivery rate of sediment and phosphorus to the lake. Alternative number 1 should be implemented in conjunction with, not as a replacement for the remaining alternatives listed later in this report.

2) Shoreline Stabilization / Management

It is recommended that 3,430 linear feet of severe and moderate shoreline erosion identified in this report be stabilized as soon as possible, and that an additional 1,150 feet of minor shoreline erosion be addressed as time and resources permit.

The shoreline stabilization management plan for Pelican Lake should include the possibility of using "soft" or non-traditional shoreline stabilization techniques. The Engineering Field Handbook (Chapter 18) (NRCS Field Office Technical Guide) should be consulted as a possible reference for these activities.

In addition to the shoreline stabilization activities described above, the following programs should be included in an overall shoreline management plan.

a) Fertilizer / Pesticide application. Fertilizers without phosphorus should be applied to lawns, only as needed. Pesticides should be used for spot treatments, rather than for application to entire lawns. Neither fertilizers or pesticides should be applied before rain events. Commercial companies should be instructed to avoid application of fertilizers and pesticides to sidewalks or driveways, to the greatest extent possible.

b) Leaf/grass disposal. Composting of grass clippings and leaves should be promoted. Mulching of grass should be encouraged to leave grass clippings on lawns, which will act as a natural fertilizer. Prevention of grass clippings, leaves, and other yard wastes from entering the lake will reduce nutrient loadings.

c) Waste oil disposal. Lake residents should be informed of facilities that will accept and recycle waste oil.

d) Construction site erosion control. Property owners and/or contractors building new homes or other facilities around the lake should be advised of techniques to control erosion. The successful implementation of this alternative may necessitate the strict enforcement of ordinances which require erosion control.

3) Ag Waste Management Systems

It is recommended that ag waste management systems be implemented at the sites identified in the AGNPS report included in Appendix B. This should include follow-up monitoring to ensure the proper disposal of wastes.

4) Septic System Alternatives

Inadequate wastewater disposal around Pelican Lake represents a potentially significant adverse impact on water quality. Alternatives to replace or improve existing individual wastewater disposal facilities (septic systems) should be investigated. An engineering feasibility study should be conducted to determine the best wastewater treatment methods.

5) Information & Education

An information and education program should be initiated to promote best management practices in prioritized areas of the watershed. This would involve the promotion of practices such as integrated crop management, which includes fertilizer and pesticide management, as well as crop residue management.

6) Selective Dredging

It was determined from the seismic sediment survey that the sediment volume in Pelican Lake is in excess of 36 million cubic yards. Although total dredging of the lake is not feasible, selective dredging in areas of deepest sedimentation would improve the fisheries habitat of the lake, and potentially reduce the release of nutrients from the bottom sediments.

7) No-Till / Crop Residue Management /Integrated Crop Management

It was demonstrated in the AGNPS model that this BMP would reduce the sedimentation and nutrient loads to Pelican Lake. This is an ongoing program through the National Resource Conservation Service (formerly Soil Conservation Service). The scale would be increased to provide more immediate control of the sheet and rill erosion from cropland not currently under this practice.

8) Grassed Waterways

Grassed waterways should be constructed or repaired to control erosion from cropland fields. These waterways would decrease sheet and rill erosion, and help to retain topsoil. The linear feet of waterways recommended in the AGNPS report (Appendix B) should be consulted to develop a management strategy.

9) Conservation Reserve Program (CRP)

The Conservation Reserve Program should be utilized to the fullest extent possible.

10) Streambank Stabilization / Riparian Area Management

Implementation of grazing management on pastureland and rangeland is a conservation practice that should be promoted to stabilize streambanks and improve riparian areas. This practice would include rotational grazing and the development of off-site watering facilities (dug-outs or wells).

11) Construction of Small Ponds/Dams

This practice would involve the installation of small dams on tributaries in the watershed. The resulting ponds (two- to three-acre impoundments) would help control flood waters and decrease sedimentation of the lake.

12) Wetland Restoration

Through the implementation of this practice, wetlands that have been partially drained and farmed could be restored. In addition, areas in priority subwatersheds should be investigated for the creation of new wetlands. These restored and newly created wetlands would function to retain sediments and nutrients.

The following alternatives pertain to the Upper Big Sioux River Watershed above Pelican Lake, including the Mud/Gravel Creek subwatershed identified in the 1994 Lake Kampeska Diagnostic/Feasibility Study.

UPPER BIG SIOUX RIVER WATERSHED ALTERNATIVES

1) Construction of Small Ponds/Dams
This alternative would involve the installation of small dams on tributaries in the Big Sioux River watershed. The resulting ponds (two- to three-acre impoundments) would help control flood waters, and decrease the sedimentation of the lake.

2) Grassed Waterways
An alternative for the control of erosion from cropland would be the installation of waterways in cropland fields. These waterways would decrease sheet and rill erosion, and help to retain sediment.

3) Filter Strips/Grass Seedings
The planting of permanent grass or grass/alfalfa mixtures in cropland areas adjacent to the Big Sioux River and its tributaries would reduce sediment loadings from the watershed. This alternative would be implemented through programs available from the ASCS; SCS; SD Game, Fish and Parks; and the SD Department of Agriculture, Division of Conservation and Forestry.

4) Animal Waste Management Systems
An alternative to control the runoff from livestock feeding areas is the construction of animal waste management systems. Other alternatives may include diversions of clean water away from livestock feeding areas, or planting of vegetative buffer strips between feeding areas and receiving waters.

5) Streambank Stabilization/Riparian Area Management
This alternative would involve the implementation of grazing management on pastureland or rangeland. It would also include rotational grazing and offsite water development (dugouts or wells). Canoe trips down the Big Sioux River in May, 1993, revealed many areas that have severe streambank erosion. In addition, areas of extreme sheet and rill erosion adjacent to the river were observed. The areas of streambank erosion and cropland field erosion were documented by photography and videotape. In addition, these areas were documented on maps and aerial photos which are on file at the Codington Conservation District office in Watertown, South Dakota.

6) Wetland Restoration/Creation
Under this alternative, wetlands that have been partially drained and farmed would be restored. Other areas would be investigated in priority subwatersheds for the creation of new wetlands. These restored and created wetlands would act as sediment sinks and nutrient filters.

7) Conservation Reserve Program (CRP)
The bidding system for the CRP program has changed to be competitive nationwide based on environmental benefits. Consequently, land that is definitely eligible has no guarantee of being accepted. However, the CRP program should be utilized to the fullest extent possible.

8) Septic System Survey
A survey of septic tank systems could be conducted in priority subwatersheds to determine their impact upon the trophic state of the lake. This would include landowner education in the proper location and maintenance of septic tanks and drainfields, as well as the modification of existing deficient systems to meet the current state rules for the design and function of septic tank systems.

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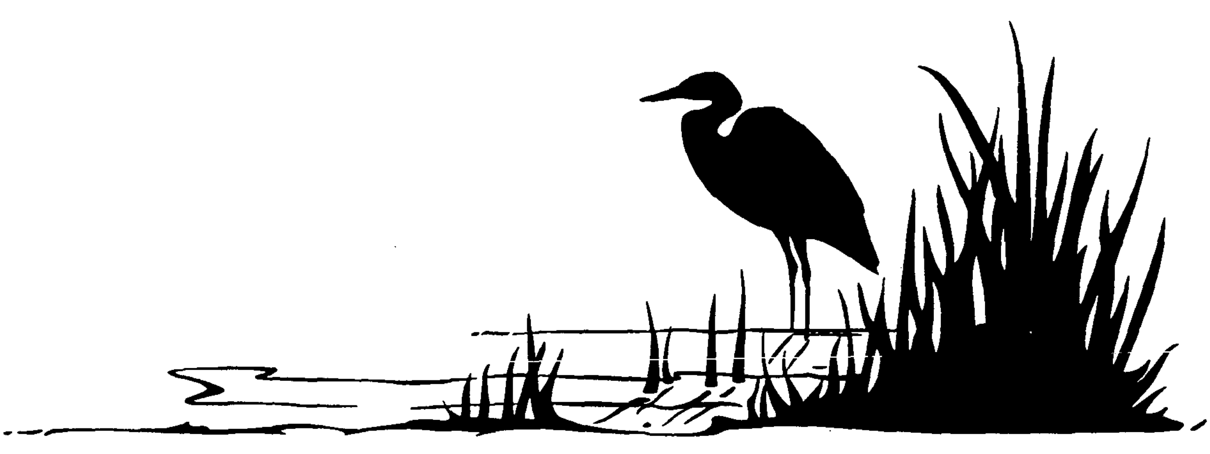
APPENDIX A.

TRIBUTARY DATA TABLES



SAMPLE DATA FOR SITE PL-1 (STATE PARK), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
15-Mar-94	1400	PL-1	54093798	5031	11522	10711	811	21.10	0.0407	64.91	148.76	25.749	20.339
16-Mar-94	1600	PL-1	32319271	3975	9146	8855	291	8.40	0.0264	32.32	77.89	13.865	10.665
17-Mar-94			20600171	4244	9043	8930	113	2.88	0.0116	11.33	37.70	6.170	4.800
18-Mar-94			24563624	5060	10783	10648	135	3.44	0.0139	13.51	44.95	7.357	5.723
19-Mar-94			24563624	5060	10783	10648	135	3.44	0.0139	13.51	44.95	7.357	5.723
20-Mar-94			24563624	5060	10783	10648	135	3.44	0.0139	13.51	44.95	7.357	5.723
21-Mar-94			19719404	4062	8657	8548	108	2.76	0.0111	10.85	36.09	5.906	4.595
22-Mar-94			4721892	973	2073	2047	26	0.66	0.0027	2.60	8.64	1.414	1.100
23-Mar-94			3547535	731	1557	1538	20	0.50	0.0020	1.95	6.49	1.062	0.827
24-Mar-94	1400	PL-1	4721892	1365	2810	2800	9	0.09	0.0005	0.47	5.90	0.803	0.642
25-Mar-94			3718796	1201	2434	2427	7	0.07	0.0006	0.37	4.43	0.502	0.389
26-Mar-94			3229480	1043	2114	2107	6	0.06	0.0005	0.32	3.84	0.436	0.337
27-Mar-94			3425207	1106	2242	2235	7	0.07	0.0006	0.34	4.08	0.462	0.358
28-Mar-94			3058220	988	2002	1995	6	0.06	0.0005	0.31	3.64	0.413	0.320
29-Mar-94			2691234	869	1761	1756	5	0.05	0.0004	0.27	3.20	0.363	0.281
30-Mar-94			2691234	869	1761	1756	5	0.05	0.0004	0.27	3.20	0.363	0.281
31-Mar-94	1115	PL-1	2691234	961	1922	1916	5	0.05	0.0007	0.27	3.04	0.269	0.196
01-Apr-94			2691234	961	1919	1912	7	0.05	0.0006	0.27	2.88	0.242	0.196
02-Apr-94			2935891	1048	2093	2086	7	0.06	0.0006	0.29	3.14	0.264	0.214
03-Apr-94			2886960	1031	2058	2051	7	0.06	0.0006	0.29	3.09	0.260	0.211
04-Apr-94			2886960	1031	2058	2051	7	0.06	0.0006	0.29	3.09	0.260	0.211
05-Apr-94			2177453	777	1553	1547	5	0.04	0.0005	0.22	2.33	0.196	0.159
06-Apr-94	1230	PL-1	1957261	699	1394	1388	6	0.04	0.0004	0.20	1.98	0.157	0.143
07-Apr-94			1957261	703	1459	1454	5	0.04	0.0005	0.20	1.96	0.137	0.127
08-Apr-94			1541343	553	1149	1145	4	0.03	0.0004	0.15	1.54	0.108	0.100
09-Apr-94			1883864	676	1404	1400	5	0.04	0.0004	0.19	1.88	0.132	0.122
10-Apr-94			2030658	729	1514	1509	5	0.04	0.0005	0.20	2.03	0.142	0.132
11-Apr-94			1541343	553	1149	1145	4	0.03	0.0004	0.15	1.54	0.108	0.100
12-Apr-94			1100959	395	821	818	3	0.02	0.0003	0.11	1.10	0.077	0.072
13-Apr-94	1130	PL-1	1198822	433	934	931	2	0.02	0.0003	0.12	1.19	0.072	0.068
14-Apr-94			782904	282	617	609	8	0.02	0.0003	0.08	0.92	0.073	0.059
15-Apr-94	1245	PL-1	2544439	913	2028	1980	48	0.05	0.0013	0.25	3.43	0.321	0.237
16-Apr-94			3180549	1139	2495	2455	40	0.06	0.0005	0.32	4.04	0.455	0.386
17-Apr-94			1492411	534	1171	1152	19	0.03	0.0003	0.15	1.90	0.213	0.181
18-Apr-94			1419014	508	1113	1095	18	0.03	0.0002	0.14	1.80	0.203	0.172
19-Apr-94			978630	350	768	756	12	0.02	0.0002	0.10	1.24	0.140	0.119
20-Apr-94			782904	280	614	604	10	0.02	0.0001	0.08	0.99	0.112	0.095
21-Apr-94			856302	307	672	661	11	0.02	0.0001	0.09	1.09	0.122	0.104
22-Apr-94			856302	307	672	661	11	0.02	0.0001	0.09	1.09	0.122	0.104
23-Apr-94			733973	263	576	567	9	0.01	0.0001	0.07	0.93	0.105	0.089
24-Apr-94			513781	184	403	397	6	0.01	0.0001	0.05	0.65	0.073	0.062

SAMPLE DATA FOR SITE PL-1 (STATE PARK), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
25-Apr-94			489315	175	384	378	6	0.01	0.0001	0.05	0.62	0.070	0.059
26-Apr-94			1516877	543	1190	1171	19	0.03	0.0003	0.15	1.93	0.217	0.184
27-Apr-94			3425207	1226	2687	2644	43	0.07	0.0006	0.34	4.35	0.490	0.416
28-Apr-94			2201919	788	1727	1700	28	0.04	0.0004	0.22	2.80	0.315	0.268
29-Apr-94			2544439	911	1996	1964	32	0.05	0.0004	0.25	3.23	0.364	0.309
30-Apr-94			6385564	2286	5009	4930	80	0.13	0.0011	0.64	8.11	0.913	0.776
01-May-94			4721892	1690	3704	3645	59	0.09	0.0008	0.47	6.00	0.675	0.574
02-May-94	1230	PL-1	3718796	1328	2871	2849	22	0.07	0.0002	0.37	4.43	0.595	0.558
03-May-94			3547535	864	2973	2863	110	0.27	0.0023	0.89	7.08	1.093	0.275
04-May-94			2886960	703	2419	2330	89	0.22	0.0019	0.72	5.76	0.889	0.224
05-May-94			2544439	620	2132	2053	79	0.19	0.0016	0.64	5.08	0.784	0.197
06-May-94			2201919	536	1845	1777	68	0.17	0.0014	0.55	4.39	0.678	0.171
07-May-94			2201919	536	1845	1777	68	0.17	0.0014	0.55	4.39	0.678	0.171
08-May-94			2152987	524	1804	1737	67	0.16	0.0014	0.54	4.30	0.663	0.167
09-May-94			1712603	417	1435	1382	53	0.13	0.0011	0.43	3.42	0.527	0.133
10-May-94			1100959	268	923	888	34	0.08	0.0007	0.28	2.20	0.339	0.085
11-May-94			660576	161	554	533	20	0.05	0.0004	0.17	1.32	0.203	0.051
12-May-94			611644	149	513	494	19	0.05	0.0004	0.15	1.22	0.188	0.047
13-May-94			513781	125	431	415	16	0.04	0.0003	0.13	1.02	0.158	0.040
14-May-94			1614740	393	1353	1303	50	0.12	0.0010	0.40	3.22	0.497	0.125
15-May-94			3718796	906	3116	3001	115	0.28	0.0024	0.93	7.42	1.145	0.288
16-May-94			2544439	620	2132	2053	79	0.19	0.0016	0.64	5.08	0.784	0.197
17-May-94			1345617	328	1128	1086	42	0.10	0.0009	0.34	2.68	0.414	0.104
18-May-94			733973	179	615	592	23	0.06	0.0005	0.18	1.46	0.226	0.057
19-May-94			464849	113	390	375	14	0.03	0.0003	0.12	0.93	0.143	0.036
20-May-94			269123	66	226	217	8	0.02	0.0002	0.07	0.54	0.083	0.021
21-May-94			220192	54	185	178	7	0.02	0.0001	0.06	0.44	0.068	0.017
22-May-94			220192	54	185	178	7	0.02	0.0001	0.06	0.44	0.068	0.017
23-May-94			146795	36	123	118	5	0.01	0.0001	0.04	0.29	0.045	0.011
24-May-94			122329	30	103	99	4	0.01	0.0001	0.03	0.24	0.038	0.009
25-May-94			48932	12	41	39	2	0.00	0.0000	0.01	0.10	0.015	0.004
26-May-94			48932	12	41	39	2	0.00	0.0000	0.01	0.10	0.015	0.004
27-May-94			24466	6	21	20	1	0.00	0.0000	0.01	0.05	0.008	0.002
28-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Jun-94			122329	30	103	99	4	0.01	0.0001	0.03	0.24	0.038	0.009

SAMPLE DATA FOR SITE PL-1 (STATE PARK), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
05-Jun-94	1345	PL-1	636110	83	575	539	36	0.08	0.0021	0.25	1.78	0.290	0.003
06-Jun-94			1198822	209	903	797	105	0.13	0.0018	0.36	2.92	0.701	0.378
07-Jun-94			7633318	1328	5748	5076	672	0.80	0.0117	2.29	18.59	4.462	2.408
08-Jun-94			9345921	1626	7037	6215	822	0.98	0.0144	2.80	22.76	5.463	2.949
09-Jun-94			2446576	426	1842	1627	215	0.26	0.0038	0.73	5.96	1.430	0.772
10-Jun-94			1174357	204	884	781	103	0.12	0.0018	0.35	2.86	0.686	0.371
11-Jun-94			733973	128	553	488	65	0.08	0.0011	0.22	1.79	0.429	0.232
12-Jun-94			464849	81	350	309	41	0.05	0.0007	0.14	1.13	0.272	0.147
13-Jun-94			513781	89	387	342	45	0.05	0.0008	0.15	1.25	0.300	0.162
14-Jun-94			293589	51	221	195	26	0.03	0.0005	0.09	0.71	0.172	0.093
15-Jun-94			269123	47	203	179	24	0.03	0.0004	0.08	0.66	0.157	0.085
16-Jun-94	1430	PL-1	171260	37	103	83	21	0.01	0.0001	0.03	0.35	0.122	0.107
17-Jun-94			35793409	6103	19919	17217	2702	1.79	0.0080	8.95	0.00	0.000	0.000
18-Jun-94			43597987	7433	24262	20971	3292	2.18	0.0098	10.90	81.31	29.189	24.829
19-Jun-94			8611948	1468	4793	4142	650	0.43	0.0019	2.15	16.06	5.766	4.905
20-Jun-94			4403837	751	2451	2118	332	0.22	0.0010	1.10	8.21	2.948	2.508
21-Jun-94			5602659	955	3118	2695	423	0.28	0.0013	1.40	10.45	3.751	3.191
22-Jun-94			4257042	726	2369	2048	321	0.21	0.0010	1.06	7.94	2.850	2.424
23-Jun-94			18373787	3133	10225	8838	1387	0.92	0.0041	4.59	34.27	12.301	10.464
24-Jun-94			19719404	3362	10974	9485	1489	0.99	0.0044	4.93	36.78	13.202	11.230
25-Jun-94			4257042	726	2369	2048	321	0.21	0.0010	1.06	7.94	2.850	2.424
26-Jun-94			2544439	434	1416	1224	192	0.13	0.0006	0.64	4.75	1.704	1.449
27-Jun-94			1834932	313	1021	883	139	0.09	0.0004	0.46	3.42	1.228	1.045
28-Jun-94			1370083	234	762	659	103	0.07	0.0003	0.34	2.56	0.917	0.780
29-Jun-94			293589	50	163	141	22	0.01	0.0001	0.07	0.55	0.197	0.167
30-Jun-94			244658	42	136	118	18	0.01	0.0001	0.06	0.46	0.164	0.139
01-Jul-94			195726	33	109	94	15	0.01	0.0000	0.05	0.37	0.131	0.111
02-Jul-94			171260	29	95	82	13	0.01	0.0000	0.04	0.32	0.115	0.098
03-Jul-94			122329	21	68	59	9	0.01	0.0000	0.03	0.23	0.082	0.070
04-Jul-94			122329	21	68	59	9	0.01	0.0000	0.03	0.23	0.082	0.070
05-Jul-94			122329	21	68	59	9	0.01	0.0000	0.03	0.23	0.082	0.070
06-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-1 (STATE PARK), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
16-Jul-94			856302	146	477	412	65	0.04	0.0002	0.21	1.60	0.573	0.488
17-Jul-94			1810466	309	1008	871	137	0.09	0.0004	0.45	3.38	1.212	1.031
18-Jul-94			1516877	259	844	730	115	0.08	0.0003	0.38	2.83	1.016	0.864
19-Jul-94			1443480	246	803	694	109	0.07	0.0003	0.36	2.69	0.966	0.822
20-Jul-94			1419014	242	790	683	107	0.07	0.0003	0.35	2.65	0.950	0.808
21-Jul-94			1321151	225	735	635	100	0.07	0.0003	0.33	2.46	0.885	0.752
22-Jul-94			1198822	204	667	577	91	0.06	0.0003	0.30	2.24	0.803	0.683
23-Jul-94			1149891	196	640	553	87	0.06	0.0003	0.29	2.14	0.770	0.655
24-Jul-94			929699	159	517	447	70	0.05	0.0002	0.23	1.73	0.622	0.529
25-Jul-94			880767	150	490	424	66	0.04	0.0002	0.22	1.64	0.590	0.502
26-Jul-94			807370	138	449	388	61	0.04	0.0002	0.20	1.51	0.541	0.460
27-Jul-94			758439	129	422	365	57	0.04	0.0002	0.19	1.41	0.508	0.432
28-Jul-94			636110	108	354	306	48	0.03	0.0001	0.16	1.19	0.426	0.362
29-Jul-94			611644	104	340	294	46	0.03	0.0001	0.15	1.14	0.409	0.348
30-Jul-94			587178	100	327	282	44	0.03	0.0001	0.15	1.10	0.393	0.334
31-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Aug-94			73641941	12556	40982	35422	5560	3.68	0.0165	18.41	137.34	49.303	41.939
10-Aug-94	1000	PL-1	78094710	9606	39906	37485	2421	1.56	0.0037	23.43	129.64	48.887	40.063
11-Aug-94			64834267	8745	33868	31137	2731	1.78	0.0050	18.64	110.95	41.291	34.176
12-Aug-94			12477538	1683	6518	5992	526	0.34	0.0010	3.59	21.35	7.947	6.577
13-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MINIMUM			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MAXIMUM			78094710	12556	40982	37485	5560	21.10	0.0407	64.91	148.76	49.303	41.939
MEAN			4436074.3	820	2362	2189	173	0.41	0.0016	1.74	7.81	2.044	1.629
YEARLY TOTAL (KG PER YEAR)			754132624	139408	401560	372136	29424	69.22	0.2771	295.12	1328.24	347.504	276.878

SAMPLE DATA FOR SITE PL-2 (AIR HAVEN), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
15-Mar-94	1230	PL-2	31805490	2735	6647	6107	541	105.91	0.0587	57.25	287.52	67.746	62.339
16-Mar-94	1445	PL-2	27646310	2986	7077	6746	332	97.87	0.0872	49.76	252.41	64.139	59.716
17-Mar-94			25762447	2499	5990	5616	374	88.49	0.0644	46.37	234.05	57.321	53.071
18-Mar-94			4403837	427	1024	960	64	15.13	0.0110	7.93	40.01	9.799	9.072
19-Mar-94			2324247	225	540	507	34	7.98	0.0058	4.18	21.12	5.171	4.788
20-Mar-94			318055	31	74	69	5	1.09	0.0008	0.57	2.89	0.708	0.655
21-Mar-94			122329	12	28	27	2	0.42	0.0003	0.22	1.11	0.272	0.252
22-Mar-94			1363258	97	233	218	15	3.44	0.0025	1.80	9.09	2.225	2.060
23-Mar-94			1363258	97	233	218	15	3.44	0.0025	1.80	9.09	2.225	2.060
24-Mar-94			1363258	97	233	218	15	3.44	0.0025	1.80	9.09	2.225	2.060
25-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-2 (AIR HAVEN), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
25-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-2 (AIR HAVEN), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
05-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Jun-94			33762750	7040	13564	12914	650	58.66	0.0509	32.07	241.99	89.049	87.277
18-Jun-94			3180549	663	1278	1217	61	5.53	0.0048	3.02	22.80	8.389	8.222
19-Jun-94			73397	15	29	28	1	0.13	0.0001	0.07	0.53	0.194	0.190
20-Jun-94	1315	PL-2	73397	23	42	40	2	0.00	0.0000	0.01	0.39	0.224	0.228
21-Jun-94			318055	84	155	148	7	0.28	0.0003	0.17	1.97	0.904	0.906
22-Jun-94			318055	84	155	148	7	0.28	0.0003	0.17	1.97	0.904	0.906
23-Jun-94			22263843	5883	10829	10347	481	19.79	0.0226	11.69	138.23	63.313	63.396
24-Jun-94			6116440	1616	2975	2843	132	5.44	0.0062	3.21	37.98	17.394	17.417
25-Jun-94			183493	48	89	85	4	0.16	0.0002	0.10	1.14	0.522	0.522
26-Jun-94			73397	19	36	34	2	0.07	0.0001	0.04	0.46	0.209	0.209
27-Jun-94			1678063	264	486	465	22	0.89	0.0010	0.53	6.21	2.844	2.848
28-Jun-94			1678063	264	486	465	22	0.89	0.0010	0.53	6.21	2.844	2.848
29-Jun-94			97863	26	48	45	2	0.09	0.0001	0.05	0.61	0.278	0.279
30-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-2 (AIR HAVEN), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UN-IONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
16-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Aug-94			8073701	1333	3507	3403	104	3.67	0.0048	12.56	48.92	22.150	20.886
10-Aug-94	1100	PL-2	21872391	2887	9121	8902	219	6.78	0.0101	41.56	131.45	59.274	54.681
11-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MINIMUM			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MAXIMUM			33762750	7040	13564	12914	650	105.91	0.0872	57.25	287.52	89.049	87.277
MEAN			1110530	173	382	363	18	2.53	0.0020	1.63	8.87	2.825	2.688
YEARLY TOTAL (KG PER YEAR)			188790047	29457	64878	61769	3109	429.85	0.3383	277.45	1507.22	480.322	456.885

SAMPLE DATA FOR SITE PL-3 (FOLEY ROAD), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
15-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Apr-94	1130	PL-3	8054129	3012.24	7015.15	6797.68	217.46	0.16	0.0031	69.27	38.82	5.871	5.259
16-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-3 (FOLEY ROAD), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
25-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Apr-94			951718	396.87	838.46	835.61	2.86	0.02	0.0001	0.38	2.51	0.336	0.307
27-Apr-94			1223288	511.95	990.86	987.81	3.06	0.02	0.0002	0.31	3.08	0.363	0.340
28-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Apr-94			24466	10.24	19.82	19.76	0.06	0.00	0.0000	0.01	0.06	0.007	0.007
30-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-May-94			318055	133.11	257.62	256.83	0.80	0.01	0.0000	0.08	0.80	0.094	0.088
02-May-94			611644	256.89	452.00	450.78	1.22	0.01	0.0001	0.06	1.46	0.147	0.143
03-May-94			0	0.00	0.00	0.00	0.00	0.00	0.0000	0.00	0.00	0.000	0.000
04-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Jun-94			0	0.00	0.00	0.00	0.00	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-3 (FOLEY ROAD), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
05-Jun-94			12257346	1179.16	7035.72	5662.89	1372.82	4.41	0.0392	116.44	53.69	12.870	10.443
06-Jun-94			269123	49.01	153.67	135.77	17.90	0.06	0.0005	1.44	0.99	0.258	0.212
07-Jun-94			23780720	4330.47	13578.79	11997.37	1581.42	4.99	0.0465	127.23	87.75	22.758	18.727
08-Jun-94			8807674	1603.88	5029.18	4443.47	585.71	1.85	0.0172	47.12	32.50	8.429	6.936
09-Jun-94			3376275	614.82	1927.85	1703.33	224.52	0.71	0.0066	18.06	12.46	3.231	2.659
10-Jun-94			0	0.00	0.00	0.00	0.00	0.00	0.0000	0.00	0.00	0.000	0.000
11-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Jun-94			0	0.00	0.00	0.00	0.00	0.00	0.0000	0.00	0.00	0.000	0.000
16-Jun-94			29358913	7868.19	16675.86	16059.33	616.54	1.76	0.0209	35.23	88.08	25.366	21.226
17-Jun-94			57421142	12922.63	32701.34	30189.17	2512.17	7.75	0.0766	188.05	192.07	52.282	43.367
18-Jun-94			7853509	1767.43	4472.57	4128.98	343.59	1.06	0.0105	25.72	26.27	7.151	5.931
19-Jun-94			1100959	247.77	627.00	578.83	48.17	0.15	0.0015	3.61	3.68	1.002	0.831
20-Jun-94			516228	116.18	293.99	271.41	22.58	0.07	0.0007	1.69	1.73	0.470	0.390
21-Jun-94			269123	60.57	153.27	141.49	11.77	0.04	0.0004	0.88	0.90	0.245	0.203
22-Jun-94			12232881	2753.01	6966.63	6431.44	535.19	1.65	0.0163	40.06	40.92	11.138	9.239
23-Jun-94			11523374	2593.34	6562.56	6058.41	504.15	1.56	0.0154	37.74	38.55	10.492	8.703
24-Jun-94			1100959	247.77	627.00	578.83	48.17	0.15	0.0015	3.61	3.68	1.002	0.831
25-Jun-94			489315	110.12	278.67	257.26	21.41	0.07	0.0007	1.60	1.64	0.446	0.370
26-Jun-94			2030658	457.00	1156.46	1067.62	88.84	0.27	0.0027	6.65	6.79	1.849	1.534
27-Jun-94			0	0.00	0.00	0.00	0.00	0.00	0.0000	0.00	0.00	0.000	0.000
28-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-3 (FOLEY ROAD), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
16-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Aug-94			318055	58.10	132.73	57.99	3.71	0.01	0.0001	0.21	0.93	0.277	0.241
10-Aug-94	1215	PL-3	6091975	852.88	2083.46	0.00	42.64	0.12	0.0000	2.44	17.54	5.337	4.709
11-Aug-94			73397	11.84	27.87	6.69	0.69	0.00	0.0000	0.04	0.21	0.064	0.056
12-Aug-94			24466	3.69	8.83	1.12	0.20	0.00	0.0000	0.01	0.07	0.021	0.019
13-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MINIMUM			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MAXIMUM			57,421,142	12,923	32,701	30,189	2,512	7.75	0.0766	188.05	192.07	52.282	43.367
MEAN			5,137,281	1,140	2,975	2,679	238	0.73	0.0070	19.67	17.76	4.635	3.859
YEARLY TOTAL (KG PER YEAR)			190,079,392	42,169	110,067	99,120	8,808	26.90	0.2606	727.94	657.19	171.507	142.773

SAMPLE DATA FOR SITE PL-4 (BIG SIOUX RIVER, INLET), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
15-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Mar-94	1230	PL-4	138158154	14645	35645	33711	1934	22.11	0.0756	124.34	276.32	39.513	31.224
18-Mar-94	1130	PL-4	189866540	22594	52403	49365	3038	17.09	0.0154	170.88	381.63	44.239	34.746
19-Mar-94			1035880330	145541	302477	287457	15020	124.31	0.2712	932.29	1766.18	260.524	205.104
20-Mar-94			1475799183	207350	430933	409534	21399	177.10	0.3864	1328.22	2516.24	371.163	292.208
21-Mar-94			1276750643	179383	372811	354298	18513	153.21	0.3343	1149.08	2176.86	321.103	252.797
22-Mar-94			257944967	36241	75320	71580	3740	30.95	0.0675	232.15	439.80	64.873	51.073
23-Mar-94			455657677	64020	133052	126445	6607	54.68	0.1193	410.09	776.90	114.598	90.220
24-Mar-94	1700	PL-4	513291671	83153	158094	151421	6673	76.99	0.4055	461.96	718.61	138.589	109.331
25-Mar-94			266953261	59664	115991	112788	3203	22.69	0.1191	173.52	305.66	48.052	36.439
26-Mar-94			240050709	53651	104302	101421	2881	20.40	0.1071	156.03	274.86	43.209	32.767
27-Mar-94			89116535	19918	38721	37652	1069	7.57	0.0397	57.93	102.04	16.041	12.164
28-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-4 (BIG SIOUX RIVER, INLET), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
25-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Apr-94			30885577	6903	13420	13049	371	2.63	0.0138	20.08	35.36	5.559	4.216
28-Apr-94	1300	PL-4	47524741	13545	26661	26139	523	0.95	0.0048	19.01	42.30	4.277	2.851
29-Apr-94			29711220	4234	8334	8171	431	1.34	0.0015	10.40	33.28	4.546	3.016
30-Apr-94			24475548	3488	6865	6731	355	1.10	0.0012	8.57	27.41	3.745	2.484
01-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-May-94			3043541	434	854	837	44	0.14	0.0002	1.07	3.41	0.466	0.309
03-May-94			8159331	1163	2289	2244	118	0.37	0.0004	2.86	9.14	1.248	0.828
04-May-94			3948774	563	1108	1086	57	0.18	0.0002	1.38	4.42	0.604	0.401
05-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-May-94			2473488	352	694	680	36	0.11	0.0001	0.87	2.77	0.378	0.251
14-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-May-94			8841926	1260	2480	2432	128	0.40	0.0005	3.09	9.90	1.353	0.897
18-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-4 (BIG SIOUX RIVER, INLET), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
05-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Jun-94			6395350	911	1794	1759	93	0.29	0.0003	2.24	7.16	0.978	0.649
09-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Jun-94			7809471	1113	2191	2148	113	0.35	0.0004	2.73	8.75	1.195	0.793
11-Jun-94			2546886	363	714	700	37	0.11	0.0001	0.89	2.85	0.390	0.259
12-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Jun-94			518774448	73925	145516	142663	7522	23.34	0.0264	181.57	581.03	79.372	52.656
20-Jun-94	1630	PL-4	512339952	85343	162346	175342	9222	35.86	0.9076	153.70	691.66	110.665	73.265
21-Jun-94			567948181	95273	200060	190547	13063	59.63	0.5030	113.59	837.72	141.703	91.724
22-Jun-94			404712622	67891	142560	135781	9308	42.49	0.3585	80.94	596.95	100.976	65.361
23-Jun-94			255226821	42814	89904	85629	5870	26.80	0.2261	51.05	376.46	63.679	41.219
24-Jun-94			89079837	14943	31378	29886	2049	9.35	0.0789	17.82	131.39	22.225	14.386
25-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Jul-94			2554225	428	900	857	59	0.27	0.0023	0.51	3.77	0.637	0.413
10-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-4 (BIG SIOUX RIVER, INLET), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
16-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Jul-94			4068656	683	1433	1365	94	0.43	0.0036	0.81	6.00	1.015	0.657
24-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
31-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Aug-94	1345	PL-4	72051667	13906	30550	28532	2017	10.09	0.0014	7.21	115.28	20.391	12.969
11-Aug-94			88590521	14861	31206	29722	2038	9.30	0.0793	17.72	130.67	22.103	14.307
12-Aug-94			88590521	15980	34384	32402	2259	10.85	0.0405	13.29	136.21	23.587	15.127
13-Aug-94			48931522	8826	18992	17897	1248	5.99	0.0224	7.34	75.23	13.028	8.355
14-Aug-94			15413430	2780	5982	5637	393	1.89	0.0070	2.31	23.70	4.104	2.632
15-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MINIMUM			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MAXIMUM			1475799183	207350	430933	409534	21399	177.10	0.9076	1328.22	2516.24	371.163	292.208
MEAN			165727697	25625	52497	50527	2670	17.95	0.0797	111.65	257.13	39.436	29.398
YEARLY TOTAL (KG PER YEAR)			8783567928	1358141	2782364	2677906	141525	951.37	4.2218	5917.52	13627.91	2090.130	1558.098

SAMPLE DATA FOR SITE PL-5 (BIG SIOUX RIVER, OUTLET), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
15-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
17-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
19-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
26-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
27-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Mar-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Mar-94			26038910	5182	11040	10767	273	2.21	0.0306	9.11	57.55	3.216	1.875
31-Mar-94	1030	PL-5	183233872	38846	83921	83188	733	27.49	0.2623	109.94	370.13	25.653	19.606
01-Apr-94			199227140	39646	84472	82380	2092	16.93	0.2339	69.73	440.29	24.605	14.344
02-Apr-94			192327796	38273	81547	79528	2019	16.35	0.2258	67.31	425.04	23.752	13.848
03-Apr-94			204210816	40638	86585	84441	2144	17.36	0.2398	71.47	451.31	25.220	14.703
04-Apr-94			208230540	41438	88290	86103	2186	17.70	0.2445	72.88	460.19	25.716	14.993
05-Apr-94			218268842	43435	92546	90254	2292	18.55	0.2563	76.39	482.37	26.956	15.715
06-Apr-94	1130	PL-5	239470871	44542	93394	89323	4071	4.79	0.2195	23.95	574.73	25.623	8.860
07-Apr-94			230739041	40725	89296	84566	4730	4.61	0.3078	23.07	461.48	23.881	6.576
08-Apr-94			219247473	38697	84849	80354	4495	4.38	0.2925	21.92	438.49	22.692	6.249
09-Apr-94			203356961	35893	78699	74530	4169	4.07	0.2713	20.34	406.71	21.047	5.796
10-Apr-94			181533502	32041	70253	66532	3721	3.63	0.2422	18.15	363.07	18.789	5.174
11-Apr-94			167426544	29551	64794	61362	3432	3.35	0.2234	16.74	334.85	17.329	4.772
12-Apr-94			153434575	27081	59379	56234	3145	3.07	0.2047	15.34	306.87	15.880	4.373
13-Apr-94	1230	PL-5	132875996	22190	51024	47835	3189	2.66	0.2327	13.29	212.60	13.288	2.658
14-Apr-94			164253335	28087	66030	63648	2382	3.29	0.2023	16.43	226.67	14.536	3.039
15-Apr-94			26085395	4461	10486	10108	378	0.52	0.0321	2.61	36.00	2.309	0.483
16-Apr-94			61528943	10521	24735	23842	892	1.23	0.0758	6.15	84.91	5.445	1.138
17-Apr-94			70297472	12021	28260	27240	1019	1.41	0.0866	7.03	97.01	6.221	1.301
18-Apr-94			57890884	9899	23272	22433	839	1.16	0.0713	5.79	79.89	5.123	1.071
19-Apr-94			44554598	7619	17911	17265	646	0.89	0.0549	4.46	61.49	3.943	0.824
20-Apr-94			37173278	6357	14944	14405	539	0.74	0.0458	3.72	51.30	3.290	0.688
21-Apr-94			33843488	5923	14214	14045	169	0.68	0.0241	3.38	39.26	2.606	0.575
22-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000

SAMPLE DATA FOR SITE PL-5 (BIG SIOUX RIVER, OUTLET), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
25-Apr-94			13265336	2454	5518	5392	126	0.27	0.0121	1.33	16.32	1.413	0.683
26-Apr-94			2551779	472	1062	1037	24	0.05	0.0023	0.26	3.14	0.272	0.131
27-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
28-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
30-Apr-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
02-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
03-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
04-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
05-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
06-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
07-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-May-94			2546886	471	1060	1035	24	0.05	0.0023	0.25	3.13	0.271	0.131
10-May-94			15638515	2893	6506	6357	149	0.31	0.0143	1.56	19.24	1.666	0.805
11-May-94			27303790	5051	11358	11099	259	0.55	0.0250	2.73	33.58	2.908	1.406
12-May-94			7687142	1422	3198	3125	73	0.15	0.0070	0.77	9.46	0.819	0.396
13-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
16-May-94			1054474	195	439	429	10	0.02	0.0010	0.11	1.30	0.112	0.054
17-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
18-May-94			10258494	1898	4268	4170	97	0.21	0.0094	1.03	12.62	1.093	0.528
19-May-94			6510339	1204	2708	2646	62	0.13	0.0060	0.65	8.01	0.693	0.335
20-May-94			2551779	472	1062	1037	24	0.05	0.0023	0.26	3.14	0.272	0.131
21-May-94			15151646	2803	6303	6159	144	0.30	0.0139	1.52	18.64	1.614	0.780
22-May-94			29464116	5451	12257	11977	280	0.59	0.0269	2.95	36.24	3.138	1.517
23-May-94			45543015	8881	18764	18126	638	0.91	0.0509	4.55	59.21	6.194	3.917
24-May-94			31815276	6284	13601	13331	270	0.64	0.0770	3.18	40.41	4.009	2.529
25-May-94			26946589	5322	11520	11291	229	0.54	0.0652	2.69	34.22	3.395	2.142
26-May-94			26831600	5299	11471	11242	228	0.54	0.0649	2.68	34.08	3.381	2.133
27-May-94			25508003	5038	10905	10688	217	0.51	0.0617	2.55	32.40	3.214	2.028
28-May-94			24436402	4826	10447	10239	208	0.49	0.0591	2.44	31.03	3.079	1.943
29-May-94			21099272	4167	9020	8841	179	0.42	0.0510	2.11	26.80	2.659	1.677
30-May-94			8345271	1648	3568	3497	71	0.17	0.0202	0.83	10.60	1.052	0.663
31-May-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
01-Jun-94			2600710	514	1112	1090	22	0.05	0.0063	0.26	3.30	0.328	0.207
02-Jun-94			4993462	986	2135	2092	42	0.10	0.0121	0.50	6.34	0.629	0.397
03-Jun-94			15521079	3065	6635	6503	132	0.31	0.0375	1.55	19.71	1.956	1.234
04-Jun-94			26692146	5272	11411	11184	227	0.53	0.0646	2.67	33.90	3.363	2.122

SAMPLE DATA FOR SITE PL-5 (BIG SIOUX RIVER, OUTLET), 1994

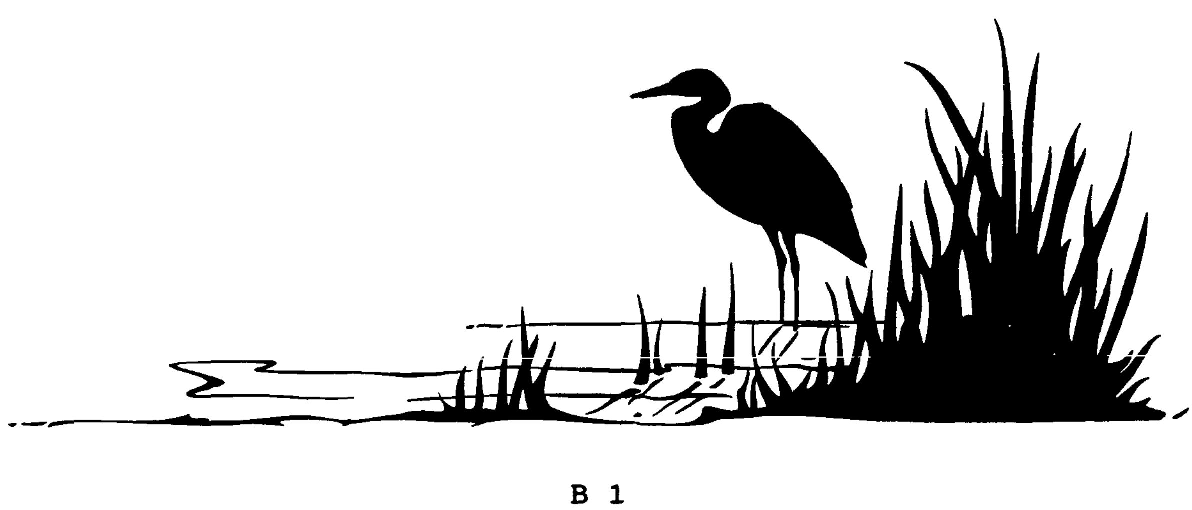
DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
05-Jun-94			40197246	7939	17184	16843	342	0.80	0.0972	4.02	51.05	5.065	3.196
06-Jun-94			14779766	2919	6318	6193	126	0.30	0.0358	1.48	18.77	1.862	1.175
07-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
08-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
09-Jun-94			3992812	789	1707	1673	34	0.08	0.0097	0.40	5.07	0.503	0.317
10-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Jun-94			7875529	1555	3367	3300	67	0.16	0.0191	0.79	10.00	0.992	0.626
13-Jun-94			7687142	1518	3286	3221	65	0.15	0.0186	0.77	9.76	0.969	0.611
14-Jun-94			6436942	1271	2752	2697	55	0.13	0.0156	0.64	8.17	0.811	0.512
15-Jun-94			2473488	489	1057	1036	21	0.05	0.0060	0.25	3.14	0.312	0.197
16-Jun-94	1600	PL-5	4800182	960	2126	2112	14	0.10	0.0179	0.48	5.95	0.557	0.350
17-Jun-94			3503497	696	1525	1505	20	0.07	0.0108	0.35	4.40	0.424	0.267
18-Jun-94			2676554	532	1165	1150	15	0.05	0.0082	0.27	3.36	0.324	0.204
19-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
20-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
21-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
22-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
23-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
25-Jun-94			46267201	9196	20138	19872	266	0.93	0.1420	4.63	58.07	5.598	3.528
26-Jun-94			15203024	3022	6617	6530	87	0.30	0.0467	1.52	19.08	1.840	1.159
27-Jun-94			7819257	1554	3403	3358	45	0.16	0.0240	0.78	9.81	0.946	0.596
28-Jun-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
29-Jun-94			5245459	1043	2283	2253	30	0.10	0.0161	0.52	6.58	0.635	0.400
30-Jun-94			2600710	517	1132	1117	15	0.05	0.0080	0.26	3.26	0.315	0.198
01-Jul-94			4939637	982	2150	2122	28	0.10	0.0152	0.49	6.20	0.598	0.377
02-Jul-94			6515232	1295	2836	2798	37	0.13	0.0200	0.65	8.18	0.788	0.497
03-Jul-94			5365341	1066	2335	2304	31	0.11	0.0165	0.54	6.73	0.649	0.409
04-Jul-94			4235023	842	1843	1819	24	0.08	0.0130	0.42	5.31	0.512	0.323
05-Jul-94			4939637	982	2150	2122	28	0.10	0.0152	0.49	6.20	0.598	0.377
06-Jul-94			2669215	531	1162	1146	15	0.05	0.0082	0.27	3.35	0.323	0.204
07-Jul-94			3503497	696	1525	1505	20	0.07	0.0108	0.35	4.40	0.424	0.267
08-Jul-94			2524867	502	1099	1084	15	0.05	0.0078	0.25	3.17	0.306	0.193
09-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
10-Jul-94			3170763	630	1380	1362	18	0.06	0.0097	0.32	3.98	0.384	0.242
11-Jul-94			3231927	642	1407	1388	19	0.06	0.0099	0.32	4.06	0.391	0.246
12-Jul-94			3048434	606	1327	1309	18	0.06	0.0094	0.30	3.83	0.369	0.232
13-Jul-94			2921212	581	1271	1255	17	0.06	0.0090	0.29	3.67	0.353	0.223
14-Jul-94			3342023	664	1455	1435	19	0.07	0.0103	0.33	4.19	0.404	0.255
15-Jul-94			5406933	1075	2353	2322	31	0.11	0.0166	0.54	6.79	0.654	0.412

SAMPLE DATA FOR SITE PL-5 (BIG SIOUX RIVER, OUTLET), 1994

DATE	TIME	SITE	FLOWS L/DAY	TALKAL -M KG/DAY	TSOL KG/DAY	TDSOL KG/DAY	TSSOL KG/DAY	AMMON KG/DAY	UNIONIZED AMMONIA KG/DAY	NO3+2 KG/DAY	TKN-N KG/DAY	TPO4 KG/DAY	TDPO4 KG/DAY
16-Jul-94			4550632	904	1981	1954	26	0.09	0.0140	0.46	5.71	0.551	0.347
17-Jul-94			4257042	846	1853	1828	24	0.09	0.0131	0.43	5.34	0.515	0.325
18-Jul-94			4624029	919	2013	1986	27	0.09	0.0142	0.46	5.80	0.560	0.353
19-Jul-94			4917618	977	2140	2112	28	0.10	0.0151	0.49	6.17	0.595	0.375
20-Jul-94			6434495	1279	2801	2764	37	0.13	0.0198	0.64	8.08	0.779	0.491
21-Jul-94			3987919	793	1736	1713	23	0.08	0.0122	0.40	5.00	0.483	0.304
22-Jul-94			2549332	507	1110	1095	15	0.05	0.0078	0.25	3.20	0.308	0.194
23-Jul-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
24-Jul-94			5729881	1139	2494	2461	33	0.11	0.0176	0.57	7.19	0.693	0.437
25-Jul-94			5507243	1095	2397	2365	32	0.11	0.0169	0.55	6.91	0.666	0.420
26-Jul-94			4993462	992	2173	2145	29	0.10	0.0153	0.50	6.27	0.604	0.381
27-Jul-94			4553078	905	1982	1956	26	0.09	0.0140	0.46	5.71	0.551	0.347
28-Jul-94			3973240	790	1729	1707	23	0.08	0.0122	0.40	4.99	0.481	0.303
29-Jul-94			4707212	936	2049	2022	27	0.09	0.0145	0.47	5.91	0.570	0.359
30-Jul-94			6884665	1368	2997	2957	40	0.14	0.0211	0.69	8.64	0.833	0.525
31-Jul-94			5661377	1125	2464	2432	33	0.11	0.0174	0.57	7.11	0.685	0.432
01-Aug-94			5240566	1042	2281	2251	30	0.10	0.0161	0.52	6.58	0.634	0.400
02-Aug-94			4557971	906	1984	1958	26	0.09	0.0140	0.46	5.72	0.552	0.348
03-Aug-94			4217897	838	1836	1812	24	0.08	0.0129	0.42	5.29	0.510	0.322
04-Aug-94			3726135	741	1622	1600	21	0.07	0.0114	0.37	4.68	0.451	0.284
05-Aug-94			2480828	493	1080	1066	14	0.05	0.0076	0.25	3.11	0.300	0.189
06-Aug-94			3973240	790	1729	1707	23	0.08	0.0122	0.40	4.99	0.481	0.303
07-Aug-94			5781259	1149	2516	2483	33	0.12	0.0177	0.58	7.26	0.700	0.441
08-Aug-94			15203024	3022	6617	6530	87	0.30	0.0467	1.52	19.08	1.840	1.159
09-Aug-94			2627623	522	1144	1129	15	0.05	0.0081	0.26	3.30	0.318	0.200
10-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
11-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
12-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
13-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
14-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
15-Aug-94			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MINIMUM			0	0	0	0	0	0.00	0.0000	0.00	0.00	0.000	0.000
MAXIMUM			239470871	44542	93394	90254	4730	27.49	0.3078	109.94	574.73	26.956	19.606
MEAN			26926748	5020	10985	10622	363	1.12	0.0406	4.92	48.78	3.002	1.386
YEARLY TOTAL (KG PER YEAR)			4173646014	778035	1702721	1646471	56250	173.22	6.3004	761.94	7560.35	465.240	214.893

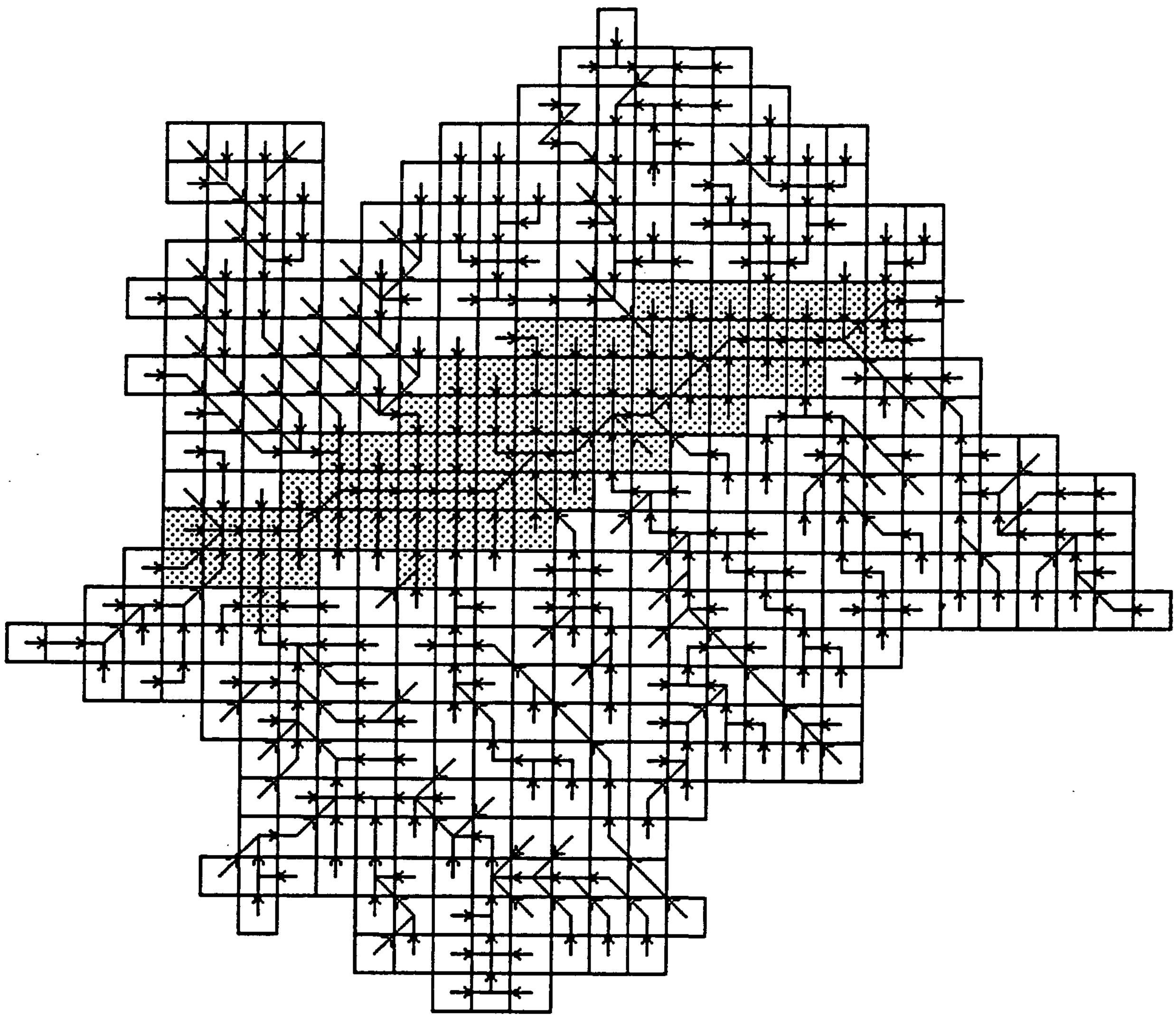
APPENDIX B.

AGRICULTURAL NONPOINT SOURCE RUNOFF MODEL REPORT



PRELIMINARY REPORT ON THE

AGRICULTURAL NONPOINT SOURCE (AGNPS) ANALYSIS OF THE PELICAN LAKE WATERSHED CODINGTON COUNTY, SOUTH DAKOTA



SOUTH DAKOTA CLEAN LAKES PROGRAM
DIVISION OF WATER RESOURCES MANAGEMENT
SOUTH DAKOTA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES

NOVEMBER 1994

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PELICAN LAKE AGNPS ANALYSIS

An analysis of the Pelican Lake watershed was performed utilizing a computer model. The model selected was the Agricultural Nonpoint Source Pollution Model (AGNPS) (version 3.65.5). This model was developed by the Agricultural Research Service to analyze the water quality of runoff events from watersheds. The model predicts runoff volume and peak rate, eroded and delivered sediment, nitrogen, phosphorous, and chemical oxygen demand (COD) concentrations in the runoff and sediment for a single storm event for all points in the watershed. Proceeding from the headwaters to the outlet, the pollutants are routed in a step-wise fashion so the flow at any point may be examined. This model was developed to estimate subwatershed or tributary loadings to a water body. The AGNPS model is intended to be used as a tool to **objectively** compare different watersheds throughout the state. This model is intended for watersheds up to 76,000 acres (1900 cells @ 40 acres/ cell).

The size of the Pelican Lake watershed and area modeled was approximately 17,000 acres. The watershed was divided into subwatersheds based on flow and drainage patterns. This resulted in the watershed being divided into 12 subwatersheds along with direct overland flow from cells adjacent to Pelican Lake. Nonpoint Source (NPS) loadings, feedlot contributions and hydrology were computed for each subwatershed in order to determine the loadings into Pelican Lake. The amount of NPS loadings deposited in Pelican Lake and transported out of the lake were **not** calculated.

AGNPS GOALS

The primary objectives of running AGNPS on the Pelican Lake watershed was to:

1.) Evaluate and quantify the loadings from each subwatershed and their net loading to the lake.
2.) Define critical cells within each subwatershed (high sediment, nitrogen, phosphorous).
3.) Quantify the nutrient loadings from each feedlot and priority rank each feedlot.

The following is a brief overview of each objective.

OBJECTIVE 1 - AGNPS SUBWATERSHED LOADINGS TO PELICAN LAKE

SUBWATERSHED CROSS REFERENCE (SEE FIGURES ON PAGES 38, 39)

SUBWATERSHED	DRAINAGE AREA	OUTLET CELL #	MONITORING SITE
1	680	170	
2	680	150	
3	720	151	
4	1720	95	
5	720	78	
6	440	268	
7	2760	300	SITE 1
8	920	248	
9	520	225	
10	1800	201	SITE 2
11	960	162	SITE 3
12	1240	143	
OUTLET	17000	103	

TRIBUTARY LOADING - PER ACRE

SITE	DRAINAGE AREA (ACRES)	SEDIMENT TON/AC/YR (ANN.+1YR)	SEDIMENT TON/AC/YR (25YR.EVT)	TOT.NITRO. TON/AC/YR (ANN.+1YR)	TOT.NITRO. TON/AC/YR (25YR.EVT)	TOT.PHOS. TON/AC/YR (ANN.+1YR)	TOT.PHOS. TON/AC/YR (25YR.EVT)
1	680	.17	.46	.0038	.0030	.00100	.00099
2	680	.21	.51	.0128	.0062	.00279	.00166
3	720	.02	.08	.0078	.0044	.00174	.00110
4	1720	.26	.63	.0077	.0045	.00180	.00132
5	720	.02	.12	.0048	.0028	.00100	.00071
6	440	.32	.80	.0028	.0026	.00084	.00095
7	2760	.17	.47	.0052	.0038	.00136	.00121
8	920	.11	.66	.0051	.0041	.00118	.00128
9	520	.17	.82	.0034	.0052	.00097	.00173
10	1800	.54	1.25	.0095	.0068	.00262	.00231
11	960	.45	.98	.0065	.0050	.00171	.00151
12	1240	.19	.43	.0046	.0029	.00112	.00085
MEAN		.22	.60	.0062	.0043	.00151	.00130
MEDIAN		.18	.57	.0052	.0043	.00127	.00125
SSTD		.16	.33	.0029	.0014	.00065	.00045
MEAN + 1SSTD(σ)		.38	.93	.0091	.0057	.00216	.00175
*EXP.CRITICAL RANGE		.10 ⇒ .18	.40 ⇒ .89	.002⇒ .003	.002⇒ .003	.0005⇒.0008	.0008⇒.0012

*** - Values for smaller watersheds will be higher than larger watersheds because of the inverse relationship of loadings to distance from a nonpoint source to the lake.**

TRIBUTARY LOADING - PER SUBWATERSHED

SITE	DRAINAGE AREA (ACRES)	SEDIMENT TON/YR (ANN.+1YR)	SEDIMENT TON/YR (25YR.EVT)	TOT.NITRO. TON/YR (ANN.+1YR)	TOT.NITRO. TON/YR (25YR.EVT)	TOT.PHOS. TON/YR (ANN.+1YR)	TOT.PHOS. TON/YR (25YR.EVT)
1	680	111	312	2.6	2.0	.7	.7
2	680	142	349	8.7	4.2	1.9	1.1
3	720	20	55	5.6	3.2	1.3	.8
4	1720	460	1080	13.2	7.7	3.1	2.3
5	720	19	88	3.5	2.0	.7	.5
6	440	141	353	1.2	1.1	.4	.4
7	2760	486	1296	14.3	10.5	3.8	3.4
8	920	99	612	4.7	3.8	1.1	1.2
9	520	87	427	1.8	2.7	.5	.9
10	1800	981	2250	17.1	12.2	4.7	4.2
11	960	433	944	6.2	4.8	1.6	1.4
12	1240	241	536	5.7	3.6	1.4	1.1
DIRECT	1080	---	---	---	---	---	---
PELICAN LAKE	2760	---	---	---	---	---	---
TOTAL LOADINGS	17000 13160	3220	8302	84.6	57.8	21.2	18.0

AGNPS data indicates that subwatersheds 10 & 11 have the largest per acre impact on sediment loadings to Pelican Lake (≥+1 σ (sample standard deviation)). Subwatershed 10 also has elevated nitrogen and phosphorous loadings (> +1 σ). Subwatershed 2 also appears to have elevated nitrogen and phosphorous loadings. However, this can probably be attributed to the high percentage of row crops and level of fertilization (no feedlots present). Comparing AGNPS loading data to other watersheds (expected critical range), the NPS loadings appear to be high. This can be attributed to the fact that as the size of the subwatersheds decrease, the distance from the NPS source to the lake decrease, thereby resulting in higher mean values. Overall, the sediment erosion rates in watersheds 10 and 11 appear to be above normal while the nitrogen and phosphorous loadings in sub watersheds 10 and 2 appear to be above normal. Based upon this analysis, It is recommended that conservation practices be concentrated in subwatersheds 10, 11 and 2.

OBJECTIVE 2 - IDENTIFICATION OF CRITICAL CELLS (25 YEAR EVENT)

SUB WATERSHED	DRAINAGE AREA (ACRES)	NUM. CELLS WITH EROSION > 3.0 TON/AC.	%	NUM. CELLS WITH TOTAL NIT. >25.0 ppm	%	NUM. CELLS WITH TOTAL PHOS. >5.0 ppm	%	NUM. OF FEEDLOTS IN SUB WATERSHED
1	680	1	6	0	0	0	0	0
2	680	5	29	0	0	0	0	0
3	720	3	17	3	17	3	17	1
4	1720	0	0	0	0	0	0	3
5	720	0	0	1	6	2	11	1
6	440	3	27	0	0	0	0	0
7	2760	2	3	0	0	0	0	4
8	920	0	0	0	0	0	0	1
9	520	1	8	2	15	2	15	1
10	1800	4	9	1	2	2	4	4
11	960	0	0	3	13	3	13	3
12	1240	2	6	0	0	0	0	1

Number of critical cells within 6 cells (8000 feet or 1.5 miles) of lake

Erosion - 16 out of 21 (76%)
Nitrogen - 7 out of 10 (70%)
Phosphorous - 9 out of 12 (75%)
Feedlots - 13 out of 20 (65%)

Priority erosion cells

14 3.87 ton/ac
65 5.29 "
66 3.58 "
86 3.58 "
87 3.46 "
130 6.35 "
131 3.57 "
150 3.25 "
169 5.02 "
188 3.34 "
250 4.34 "
256 4.34 "
261 3.25 "
280 3.34 "
296 3.53 "
297 4.84 "
298 4.02 "
336 3.10 "
351 3.25 "
371 4.45 "
403 4.96 "

Priority feedlots

332 (#1 ranked) 76
87 (#2 ranked) 55
40 (#3 ranked) 54
391 (#4 ranked) 54
387 (#5 ranked) 52

Rank Adjusted For Distance from Streams & Lake

#332 (#1 ranked) 61
92 (#2 ranked) 42
#387 (#3 ranked) 42
#322 (#4 ranked) 38
#385 (#5 ranked) 36

Priority nitrogen cells

40 27.25 ppm
87 46.17 "
108 30.58 "
130 25.39 "
259 26.86 "
279 28.95 "
286 31.34 "
287 52.19 "
309 34.22 "
335 105.75 "

Priority phosphorous cells

40 7.78 ppm
41 5.57 "
87 10.92 "
108 7.15 "
130 5.89 "
257 5.73 "
259 5.55 "
279 6.35 "
286 6.47 "
287 9.81 "
309 7.53 "
335 22.81 "

CRITICAL CELLS IN SUB WATERSHEDS 2, 10 AND 11

SUB WATERSHED 2 (150)

Cell	Sediment (tons/ acre)	Nitrogen (ppm)	Phosphorous (ppm)
15	———	21.22	4.98
16	———	21.22	4.98
17	———	21.22	4.98
31	———	21.22	4.98
46	———	18.36	———
86	———	18.74	———

SUB WATERSHED 10 (201)

Cell	Sediment (tons/ acre)	Nitrogen (ppm)	Phosphorous (ppm)
201	2.84	———	———
203	———	21.22	4.98
226	———	21.22	4.98
230	2.84	———	———
256	4.34	———	———
257	———	24.65	5.73
280	3.34	———	———
284	2.84	———	———
311	———	18.93	———
313	2.13	21.22	4.98
315	2.84	———	———
332	———	19.67	———
335	———	105.75	22.81
336	3.10	———	———
350	2.20	———	———
351	3.25	———	———
366	2.84	———	———
367	———	21.22	4.98
368	2.50	———	———
369	2.13	21.22	4.98
381	———	21.22	4.98

SUB WATERSHED 11 (162)

Cell	Sediment (tons/ acre)	Nitrogen (ppm)	Phosphorous (ppm)
182	2.19	———	———
208	2.84	———	———
259	2.84	———	———
260	2.84	———	———
316	2.13	———	———

An analysis of the Pelican Lake watershed indicates that there are approximately 21 cells which have greater than 3.0 tons/ acre of sediment yield. This is approximately 6 % of the cells found within the watershed. The model also estimated that there are 10 cells which have nitrogen yields of > 25 ppm and 12 cells which have phosphorous yields > 5.0 ppm. This is approximately 2.5 % of the cells within the watershed. The location and yields for each of these cells are listed on pages 69-71. These cells should be given high priority when installing any future Best Management Practices (BMP's). The model also indicated that sub-watersheds 10, 11 and 2 have the largest sediment/ nutrient per acre loadings. Therefore BMP's should be concentrated in these three subwatersheds. The cells listed on this page and detailed on pages 76-87 should be targeted for the implementation of appropriate BMP's.

OBJECTIVE 3 - FEEDLOT RANKINGS (25 YEAR EVENT)

A total of 20 feedlots were identified in the Pelican Lake watershed. Below is a listing of the AGNPS analysis of the feedlots:

FEEDLOT (CELL,#)	SUBWATERSHED LOCATION	AGNPS RATING (25 YR.EVT)	RANKING PRIORITY	VARIANCE FROM MEAN OF 33.7	VARIANCE FROM 1 STD.DEV. (σ=19.1) FROM MEAN	PRIORITY RANK BASED ON AGNPS RANK AND DISTANCE FACTORS ♦		
						C.FACT.	C.RATE	C.RANK
9	4	15	17	- 18.7	- 0.98	.80	12	16
22	4	31	11	- 2.7	- 0.14	.90	28	10
40	5	54	3	+ 20.3	+ 1.06	.54	29	9
87	3	55	2	+ 21.3	+ 1.11	.54	30	8
92	4	42	7	+ 8.3	+ 0.43	1.00	42	2
205	11	0	20	- 33.1	- 1.76	.72	0	20
208	11	14	18	- 19.7	- 1.03	.54	8	19
238	12	13	19	- 20.7	- 1.08	.80	10	18
240	DIRECT	22	13	- 11.7	- 0.61	1.00	22	12
257	10	18	16	- 15.7	- 0.82	.80	14	14
283	10	39	9	+ 5.3	+ 0.28	.80	31	7
287	11	21	14	- 12.7	- 0.66	.64	13	15
309	9	39	10	+ 5.3	+ 0.28	.90	35	6
322	7	42	8	+ 8.3	+ 0.43	.90	38	4
332	10	76	1	+ 42.3	+ 2.21	.80	61	1
335	10	22	12	- 11.7	- 0.61	.80	18	13
385	7	45	6	+ 11.3	+ 0.59	.80	36	5
387	7	52	5	+ 18.3	+ 0.96	.80	42	3
391	8	54	4	+ 20.3	+ 1.01	.48	26	11
417	7	20	15	- 13.7	- 0.72	.56	11	17

♦ - PRIORITY RANK = AGNPS 25 YEAR FEEDLOT RATING X DISTANCE TO STREAM X DISTANCE TO LAKE

DISTANCE TO STREAM FACTORS

```
Adjacent to stream           = 1.0
Within 1 cell  (1300 feet) =  .8
Within 2 cells (2600 feet) =  .6
Within 3 cells (3900 feet) =  .4
Within 4 cells (5200 feet) =  .2

Mean value      = 25.3
Median value    = 27.0
STDS            = 14.8
Mean + 1STDS    = 40.1
```

DISTANCE TO LAKE FACTORS

```
Adjacent to lake                 = 1.0
Within  4 cells (5200 feet)  =  .9
Within  8 cells (10400 feet) =  .8
Within 16 cells (15600 feet) =  .7
Within 20 cells (20800 feet) =  .6
```

FEEDLOT SELECTION CRITERIA AND STATISTICS (NOT WEIGHTED FOR DISTANCE FACTORS)

1.) Animal feedlot ranking	25 year event
2.) Range of feedlot rankings	0 - 76
3.) Mean	33.7
4.) Sample standard deviation (σ)	19.1
5.) Feedlots with rating $\geq +1\ \sigma$ are :	Cell 40, 87, 332, 387, 391

```
Cell #    40 000
Nitrogen concentration (ppm)      11.097
Phosphorus concentration (ppm)     3.994
COD concentration (ppm)          170.814
Nitrogen mass (lbs)              312.718
Phosphorus mass (lbs)            112.552
COD mass (lbs)                  4813.609
Animal feedlot rating number          54 (+1.06σ)
```

```
Cell #    87 000
Nitrogen concentration (ppm)      10.107
Phosphorus concentration (ppm)     2.450
COD concentration (ppm)           91.668
Nitrogen mass (lbs)              795.940
Phosphorus mass (lbs)            192.939
COD mass (lbs)                  7219.232
Animal feedlot rating number          55 (+1.11σ)
```

```
Cell #   332 000
Nitrogen concentration (ppm)      10.106
Phosphorus concentration (ppm)     2.216
COD concentration (ppm)           92.273
Nitrogen mass (lbs)             2554.387
Phosphorus mass (lbs)            560.050
COD mass (lbs)                 23322.640
Animal feedlot rating number          76 (+2.21σ)
```

```
Cell #   387 000
Nitrogen concentration (ppm)       6.801
Phosphorus concentration (ppm)     2.153
COD concentration (ppm)           82.053
Nitrogen mass (lbs)              365.116
Phosphorus mass (lbs)            115.578
COD mass (lbs)                  4404.751
Animal feedlot rating number          52 (+0.96σ)
```

Cell # 391 000		
Nitrogen concentration (ppm)	11.858	
Phosphorus concentration (ppm)	3.967	
COD concentration (ppm)	170.733	
Nitrogen mass (lbs)	333.121	
Phosphorus mass (lbs)	111.451	
COD mass (lbs)	4796.490	
Animal feedlot rating number	54	(+1.06σ)

Feedlots located in cells 40, 87, 332, 387 and 391 appear to be contributing excessive nutrients to the watershed (>1σ), while all other feedlots in the watershed appear to have very little impact on nutrient loading. However, feedlots located in cells 92, 322 and 385 should also be considered due to their proximity to major streams and the lake. If nutrient contributions from these 8 feedlots were eliminated, the model estimated that the nitrogen and phosphorous loadings to Pelican Lake would respectively be reduced by 17% (9.9 tons/ year, 25 year event) and 5% (.9 tons/ year, 25 year event). Another possibly source of nutrient loading is from septic systems and from livestock depositing fecal material directly into the lake or adjacent streams. Overall, the nutrients being deposited from the watershed into Pelican Lake appear to be abnormally high.

CONCLUSIONS

Based upon a comparison of other watersheds in Eastern South Dakota, the sediment and nutrient loadings to Pelican Lake appear to be high. This can be partially explained by the fact that the transport distances from a pollutant source to the lake are fairly short. However, when a subwatershed analysis is performed, above normal (> +1σ) sediment loadings were found in subwatersheds 10 (14% watershed area, 30% sediment) and 11 (7% watershed area, 13% sediment), and high nutrient loadings were found in subwatersheds 2 (5% watershed area, 10% nitrogen, 9% phosphorous, 0 feedlots) and 10 (14% watershed area, 20% nitrogen, 22% phosphorous, 4 feedlots). The implementation of appropriate Best Management Practices targeted to critical watershed cells, critical cells found within subwatersheds 10, 11 and 2 and critical feedlots should produce the most cost effective treatment plan in reducing sediment and nutrient loadings to Pelican Lake.

If you have any questions concerning this study , please contact the Department of Environment and Natural Resources at 605-773-4216.

OVERVIEW OF AGNPS DATA INPUTS

OVERVIEW

Agricultural Nonpoint Source Pollution Model (AGNPS) is a computer simulation model developed to analyze the water quality of runoff from watersheds. The model predicts runoff volume and peak rate, eroded and delivered sediment, nitrogen, phosphorous, and chemical oxygen demand concentrations in the runoff and the sediment for a **single** storm event for all points in the watershed. Proceeding from the headwaters to the outlet, the pollutants are routed in a step-wise fashion so the flow at any point may be examined. AGNPS is intended to be used as a tool to objectively evaluate the water quality of the runoff from agricultural watersheds and to present a means of objectively comparing different watersheds throughout the state.The model is intended for watersheds up to about 76,000 acres (**1900 cells** @ 40 acres/cell).

The model works on a cell basis. These cells are uniform square areas which divide up the watershed (figure 1). This division makes it possible to analyze any area, down to 1.0 acres, in the watershed. The basic components of the model are hydrology, erosion, sediment transport, nitrogen (N), phosphorous (P), and chemical oxygen demand (COD) transport. In the hydrology portion of the model, calculations are made for runoff volume and peak concentration flow. Total upland erosion, total channel erosion, and a breakdown of these two sources into five particle size classes (clay, silt, small aggregates, large aggregates, and sand) for each of the cells are calculated in the erosion portion. Sediment transport is also calculated for each of the cells in the five particle classes as well as the total. The pollutant transport portion is subdivided into one part handling soluble pollutants and another part handling sediment attached pollutants (figure 2).

PRELIMINARY EXAMINATION

A preliminary investigation of the watershed is necessary before the input file can be established. The steps to this preliminary examination are:

1) Detailed topographic map of the watershed (USGS map 1:24,000) (figure 3).
2) Establish the drainage boundaries (figure 4).
3) Divide watershed up into cells (40 acre, 1320 X 1320). Only those cells with greater than 50% of their area within the watershed boundary should be included (figure 5).
4) Number the cells consecutively from one to the number of cells (begin at NW corner of watershed and precede west to east then north to south (figure 5).
5) Establish the watershed drainage pattern from the cells (figure 5).

DATA FILE

Once the preliminary examination is completed, the input data file can be established. The data file is composed of the following 21 inputs per cell (table 1):

<u>Data input for watershed</u> (attachment 1)

1) a) Area of each cell (acres)
   b) Total number of cells in watershed
   c) Precipitation for a ___ year, 24 hour rainfall
   d) Energy intensity value for storm event previously selected

Data input for each cell

1) **Cell number** (figure 6)
2) **Receiving cell number** (figure 6)
3) **SCS number**: runoff curve number (tables 2-4), (use antecedent moisture condition II)
4) **Land slope** (topographic maps) (figure 7), average slope if irregular, water or marsh = 0
5) **Slope shape factor** (figure 8), water or marsh = 1 (uniform)
6) **Field slope length** (figure 9), water or marsh = 0, for S.D. assume slope length area 1
7) **Channel slope** (average), topo maps, if no definable channel, channel slope = 1/2 land slope, water or marsh = 0
8) **Channel sideslope**, the average sideslope (%), assume 10% if unknown, water or marsh=0
9) **Manning roughness coefficient for the channel** (table 5), If no channel exists within the cell, select a roughness coefficient appropriate for the predominant surface condition within the cell
10) **Soil erodibility factor** (attachment 2),water or marsh = 0
11) **Cropping factor** (table 6), assume conditions at storm or worst case condition (fallow or seedbed periods), water or marsh = .00, urban or residential = .01
12) **Practice factor** (table 7), worst case = 1.0, water or marsh = 0 ,urban or residential = 1.0
13) **Surface condition constant** (table 8), a value based on land use at the time of the storm to make adjustments for the time it takes overland runoff to channelize.
14) **Aspect** (figure 10), a single digit indicating the principal direction of drainage from the cell (if no drainage = 0)
15) **Soil texture,** major soil texture and number to indicate each are:

Texture	Input Parameter
Water	0
Sand	1
Silt	2
Clay	3
Peat	4

16) **Fertilization level**, indication of the level of fertilization on the field.

	Assume Fertilization (lb./acre)		
Level	N	P	Input
No fertilization	0	0	0
Low Fertilization	50	20	1
Average Fertilization	100	40	2
High Fertilization	200	80	3

avg. manure - low fertilization
high manure - avg.fertilization
water or marsh = 0
urban or residential = 0 (for normal practices)

17) **Availability factor**, (table 9) the percent of fertilizer left in the top half inch of soil at the time of the storm. Worst case 100%, water or marsh = 0, urban or residential = 100%.

18) **Point source indicator**: indicator of feedlot within the cell (0 = no feedlot, 1 = feedlot) (attachment 3).
19) **Gully source level**: tons of gully erosion occurring in the cell or input from a sub-watershed (attachment 4).
20) **Chemical oxygen demand (COD) demand,** (table 10) a value of COD for the land use in the cell.
21) **Impoundment factor**: number of impoundments in the cell (max. 13) (attachment 5)
    a) Area of drainage into the impoundment
    b) Outlet pipe (inches)
22) **Channel indicator**: number which designates the type of channel found in the cell (Table 11)

DATA OUTPUT AT THE OUTLET OF EACH CELL

Hydrology

Runoff volume
Peak runoff rate
Fraction of runoff generated within the cell

Sediment Output

Sediment yield
Sediment concentration
Sediment particle size distribution
Upland erosion
Amount of deposition
Sediment generated within the cell
Enrichment ratios by particle size
Delivery ratios by particle size

Chemical Output

Nitrogen
- Sediment associated mass
- Concentration of soluble material
- Mass of soluble material

Phosphorus
- Sediment associated mass
- Concentration of soluble material
- Mass of soluble material

Chemical Oxygen Demand
- Concentration
- Mass

PARAMETER SENSITIVITY ANALYSIS

The most sensitive parameters affecting sediment and chemical yields are:
- Land slope (LS)
- Soil erodibility (K)
- Cover-management factor (C)
- Curve number (CN)
- Practice factor (P)

RAINFALL SPECS FOR THE PELICAN LAKE WATERSHED STUDY

EVENT	RAINFALL	ENERGY INTENSITY
Monthly	.8	3.0
1 year	2.1	24.3
5 year	3.3	64.9
25 year	4.4	121.2
50 year	5.0	160.1

PELICAN LAKE WATERSHED (ANNUAL LOADINGS)

Watershed Summary

Watershed Studied	LAKE PELICAN WATERSHED
The area of the watershed is	17000.00 acres
The area of each cell is	40.00 acres
Type of event modeled	**Annual Loadings (♣)**
The characteristic storm precipitation is	0.80 inches
The storm energy-intensity value is	3.00

Values at the Watershed Outlet (Cell 103)

Cell number	103 000
Runoff volume	0.18 inches
Peak runoff rate	341.27 cfs
Total Nitrogen in sediment	0.01 lbs/acre
Total soluble Nitrogen in runoff	0.53 lbs/acre
Soluble Nitrogen concentration in runoff	13.05 ppm
Total Phosphorus in sediment	0.00 lbs/acre
Total soluble Phosphorus in runoff	0.11 lbs/acre
Soluble Phosphorus concentration in runoff	2.72 ppm
Total soluble Chemical Oxygen Demand in runoff	1.86 lbs/acre
Soluble Chemical Oxygen Demand concentration in runoff	45.85 ppm

Sediment Analysis at the Outlet (Cell 103, Annual Loadings)

Particle type	Area Weighted Erosion Upland (t/a)	Area Weighted Erosion Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Conc. (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.01	0.00	2	1	12.55	0.00	4.33
SILT	0.00	0.00	3	2	1.90	0.00	0.66
SAGG	0.01	0.00	1	0	2.36	0.00	0.81
LAGG	0.00	0.00	3	2	7.96	0.00	2.75
SAND	0.00	0.00	3	2	2.49	0.00	0.86
TOTAL	0.03	0.00	2	1	27.27	0.00	9.41

♣ - Annual loadings are estimated by assuming that there are 12 small rainfall events of .8" (E.I. = 3.0) in a normal year. Rainfall events of less than .8" were modeled and found to produce insignificant amounts of sediment and nutrient loadings.

Hydrology of Each Subwatershed (Annual Loadings)

-HYDR- Cell Num Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
78 000	720.00	0.02	0.15	56.70	0.14	54.04
95 000	1720.00	0.00	0.07	46.90	0.06	44.53
103 000	17000.00	0.09	0.18	344.57	0.18	341.27
143 000	1240.00	0.00	0.07	34.33	0.07	32.93
150 000	680.00	0.09	0.10	34.05	0.10	33.82
151 000	720.00	0.09	0.08	20.76	0.09	21.01
162 000	960.00	0.00	0.06	25.89	0.05	24.87
170 000	680.00	0.00	0.04	13.71	0.03	12.69
201 000	1800.00	0.02	0.06	40.60	0.06	39.82
225 000	520.00	0.02	0.02	7.98	0.02	7.75
248 000	920.00	0.09	0.04	10.99	0.04	11.54
268 000	440.00	0.00	0.03	5.74	0.03	5.23
300 000	2760.00	0.00	0.04	41.31	0.04	40.50

Sediment Analysis of Each Subwatershed (Annual Loadings)

-SED- Cell Num Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
78 000	CLAY	0.00	0.59	0.00	0.57	2
	SILT	0.00	0.24	0.00	0.13	46
	SAGG	0.00	0.33	0.00	0.00	99
	LAGG	0.00	0.32	0.00	0.01	96
	SAND	0.00	0.10	0.00	0.00	96
	TOTL	0.00	1.58	0.00	0.72	54
95 000	CLAY	0.00	18.67	0.00	18.42	1
	SILT	0.00	0.62	0.00	0.54	13
	SAGG	0.00	0.84	0.03	0.48	45
	LAGG	0.00	1.14	0.02	1.79	-35
	SAND	0.00	0.37	0.00	0.55	-32
	TOTL	0.00	21.63	0.06	21.78	0
103 000	CLAY	0.00	5.59	0.00	4.33	23
	SILT	0.00	0.65	0.00	0.66	-2
	SAGG	0.00	0.80	0.00	0.81	-2
	LAGG	0.00	2.69	0.00	2.75	-2
	SAND	0.00	0.84	0.00	0.86	-2
	TOTL	0.00	10.57	0.00	9.41	11
143 000	CLAY	0.00	8.47	0.00	8.35	1
	SILT	0.00	0.56	0.00	0.52	8
	SAGG	0.00	1.09	0.03	0.55	50
	LAGG	0.00	2.04	0.02	1.76	14
	SAND	0.00	0.64	0.00	0.55	14
	TOTL	0.00	12.80	0.05	11.74	9
150 000	CLAY	0.00	3.63	0.16	3.73	2
	SILT	0.01	0.17	0.26	0.38	10
	SAGG	0.04	0.22	1.61	1.01	45
	LAGG	0.02	0.07	1.00	1.33	-20
	SAND	0.00	0.02	0.19	0.42	-49
	TOTL	0.08	4.10	3.22	6.88	6

151 000	CLAY	0.00	1.46	0.00	0.40	72
	SILT	0.00	0.84	0.00	0.05	94
	SAGG	0.00	2.02	0.00	0.06	97
	LAGG	0.00	0.72	0.00	0.21	71
	SAND	0.00	0.22	0.00	0.07	70
	TOTL	0.00	5.26	0.00	0.80	85
162 000	CLAY	0.00	18.67	0.00	18.46	1
	SILT	0.00	0.34	0.00	0.33	4
	SAGG	0.00	0.44	0.03	0.39	17
	LAGG	0.00	2.01	0.02	1.24	39
	SAND	0.00	0.64	0.00	0.39	39
	TOTL	0.00	22.09	0.05	20.81	6
170 000	CLAY	0.00	5.08	0.06	4.82	6
	SILT	0.00	0.30	0.00	0.05	82
	SAGG	0.00	0.64	0.00	0.01	98
	LAGG	0.00	0.13	0.00	0.04	73
	SAND	0.00	0.04	0.00	0.01	71
	TOTL	0.00	6.18	0.06	4.93	21
201 000	CLAY	0.07	42.31	2.81	44.54	1
	SILT	0.00	0.80	0.00	0.59	26
	SAGG	0.00	1.15	0.00	0.21	82
	LAGG	0.00	3.44	0.00	0.35	90
	SAND	0.00	1.08	0.00	0.11	90
	TOTL	0.07	48.78	2.81	45.80	11
225 000	CLAY	0.05	0.02	2.16	2.10	4
	SILT	0.00	0.02	0.00	0.01	67
	SAGG	0.00	0.02	0.00	0.01	67
	LAGG	0.00	0.08	0.00	0.03	67
	SAND	0.00	0.02	0.00	0.01	67
	TOTL	0.05	0.16	2.16	2.14	8
248 000	CLAY	0.00	15.78	0.00	0.05	100
	SILT	0.00	0.02	0.00	0.06	-61
	SAGG	0.00	0.00	0.00	0.11	-98
	LAGG	0.00	0.01	0.00	0.37	-98
	SAND	0.00	0.00	0.00	0.12	-98
	TOTL	0.00	15.81	0.00	0.70	96
268 000	CLAY	0.00	7.80	0.00	6.12	22
	SILT	0.00	0.24	0.00	0.00	99
	SAGG	0.00	0.60	0.00	0.00	100
	LAGG	0.00	0.22	0.00	0.01	97
	SAND	0.00	0.07	0.00	0.00	96
	TOTL	0.00	8.93	0.00	6.13	31
300 000	CLAY	0.01	20.41	0.22	20.39	1
	SILT	0.00	0.44	0.00	0.35	22
	SAGG	0.00	0.55	0.00	0.17	69
	LAGG	0.00	3.11	0.00	0.31	90
	SAND	0.00	0.99	0.00	0.10	90
	TOTL	0.01	25.50	0.22	21.32	17

Condensed Soil Loss (Annual Loadings)

Cell Num	Div	Drainage Area (acres)	RUNOFF Vol. (in.)	RUNOFF Generated Above (%)	RUNOFF Peak Rate (cfs)	SEDIMENT Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	SEDIMENT Generated Within (tons)	SEDIMENT Yield (tons)	SEDIMENT Depo (%)
78	000	720.00	0.02	99.0	54.04	0.00	1.58	0.00	0.72	54
95	000	1720.00	0.00	99.9	44.53	0.00	21.63	0.06	21.78	0
103	000	17000.00	0.09	99.9	341.27	0.00	10.57	0.00	9.41	11
143	000	1240.00	0.00	99.8	32.93	0.00	12.80	0.05	11.74	9
150	000	680.00	0.09	94.9	33.82	0.08	4.10	3.22	6.88	6
151	000	720.00	0.09	94.1	21.01	0.00	5.26	0.00	0.80	85
162	000	960.00	0.00	99.8	24.87	0.00	22.09	0.05	20.81	6
170	000	680.00	0.00	100.0	12.69	0.00	6.18	0.06	4.93	21
201	000	1800.00	0.02	99.3	39.82	0.07	48.78	2.81	45.80	11
225	000	520.00	0.02	94.3	7.75	0.05	0.16	2.16	2.14	8
248	000	920.00	0.09	91.1	11.54	0.00	15.81	0.00	0.70	96
268	000	440.00	0.00	98.5	5.23	0.00	8.93	0.00	6.13	31
300	000	2760.00	0.00	100.0	40.50	0.01	25.50	0.22	21.32	17

Nutrient Analysis (Annual Loadings)
N I T R O G E N

Cell Num	Div	Drainage Area (acres)	Sediment Within Cell (lbs/a)	Sediment Cell Outlet (lbs/a)	Water Soluble Within Cell (lbs/a)	Water Soluble Cell Outlet (lbs/a)	Water Soluble Conc (ppm)
78	000	720.00	0.02	0.01	0.15	0.56	17.33
95	000	1720.00	0.02	0.10	0.01	0.81	55.45
103	000	17000.00	0.00	0.01	0.15	0.53	13.05
143	000	1240.00	0.02	0.08	0.07	0.46	30.12
150	000	680.00	0.42	0.08	1.21	1.52	65.14
151	000	720.00	0.00	0.02	0.15	0.90	46.82
162	000	960.00	0.02	0.15	0.01	0.58	47.56
170	000	680.00	0.03	0.09	0.00	0.33	42.83
201	000	1800.00	0.57	0.25	0.22	0.86	62.40
225	000	520.00	0.46	0.06	0.22	0.23	40.95
248	000	920.00	0.00	0.01	0.15	0.54	54.41
268	000	440.00	0.00	0.12	0.15	0.18	31.30
300	000	2760.00	0.07	0.10	0.00	0.49	52.42

Nutrient Analysis (Annual Loadings)
P H O S P H O R U S

Cell Num	Div	Drainage Area (acres)	---- Sediment ---- Within Cell (lbs/a)	Cell Outlet (lbs/a)	----- Water Soluble ------ Within Cell (lbs/a)	Cell Outlet (lbs/a)	Conc (ppm)
78	000	720.00	0.01	0.01	0.00	0.11	3.45
95	000	1720.00	0.01	0.05	0.00	0.16	11.05
103	000	17000.00	0.00	0.00	0.00	0.11	2.72
143	000	1240.00	0.01	0.04	0.00	0.09	5.84
150	000	680.00	0.21	0.04	0.24	0.30	12.96
151	000	720.00	0.00	0.01	0.21	0.19	9.98
162	000	960.00	0.01	0.07	0.00	0.12	9.42
170	000	680.00	0.01	0.05	0.00	0.06	8.42
201	000	1800.00	0.28	0.13	0.04	0.17	12.47
225	000	520.00	0.23	0.03	0.04	0.05	9.66
248	000	920.00	0.00	0.01	0.00	0.11	10.79
268	000	440.00	0.00	0.06	0.00	0.03	5.20
300	000	2760.00	0.04	0.05	0.00	0.10	10.71

Nutrient Analysis (Annual Loadings)
Chemical Oxygen Demand

Cell Num	Div	Drainage Area (acres)	---- Sediment ---- Within Cell (lbs/a)	Cell Outlet (lbs/a)	----- Water Soluble ------ Within Cell (lbs/a)	Cell Outlet (lbs/a)	Conc (ppm)
78	000	720.00			0.00	3.74	115.26
95	000	1720.00			0.00	2.35	161.64
103	000	17000.00			0.00	1.86	45.85
143	000	1240.00			5.00	2.00	129.96
150	000	680.00			3.00	4.05	173.20
151	000	720.00			0.00	3.25	168.07
162	000	960.00			0.00	1.95	159.27
170	000	680.00			0.00	0.83	108.59
201	000	1800.00			1.00	4.20	304.45
225	000	520.00			1.00	1.66	299.18
248	000	920.00			0.00	1.58	158.08
268	000	440.00			0.00	0.60	103.88
300	000	2760.00			0.00	1.29	137.82

PELICAN LAKE WATERSHED SUMMARY (1 YEAR EVENT)

Watershed Summary

Watershed Studied	LAKE PELICAN WATERSHED
The area of the watershed is	17000.00 acres
The area of each cell is	40.00 acres
Type of event modeled	**1 year, 24 hour**
The characteristic storm precipitation is	2.10 inches
The storm energy-intensity value is	24.30

Values at the Watershed Outlet (Cell 103)

Cell number	103 000
Runoff volume	0.90 inches
Peak runoff rate	1631.45 cfs
Total Nitrogen in sediment	0.14 lbs/acre
Total soluble Nitrogen in runoff	2.71 lbs/acre
Soluble Nitrogen concentration in runoff	13.27 ppm
Total Phosphorus in sediment	0.07 lbs/acre
Total soluble Phosphorus in runoff	0.60 lbs/acre
Soluble Phosphorus concentration in runoff	2.93 ppm
Total soluble Chemical Oxygen Demand in runoff	18.04 lbs/acre
Soluble Chemical Oxygen Demand concentration in runoff	88.37 ppm

Feedlot Analysis (1 Year Event)

Cell #	9 000
Nitrogen concentration (ppm)	3.713
Phosphorus concentration (ppm)	0.652
COD concentration (ppm)	36.930
Nitrogen mass (lbs)	15.431
Phosphorus mass (lbs)	2.708
COD mass (lbs)	153.467
Animal feedlot rating number	0

Cell #	22 000
Nitrogen concentration (ppm)	4.950
Phosphorus concentration (ppm)	1.374
COD concentration (ppm)	53.979
Nitrogen mass (lbs)	77.488
Phosphorus mass (lbs)	21.513
COD mass (lbs)	845.061
Animal feedlot rating number	24

Cell #	40 000
Nitrogen concentration (ppm)	22.137
Phosphorus concentration (ppm)	9.154
COD concentration (ppm)	421.401
Nitrogen mass (lbs)	188.784
Phosphorus mass (lbs)	78.060
COD mass (lbs)	3593.628
Animal feedlot rating number	49

Feedlot Analysis (1 Year Event)

Cell # 87 000	
Nitrogen concentration (ppm)	10.418
Phosphorus concentration (ppm)	2.748
COD concentration (ppm)	106.972
Nitrogen mass (lbs)	256.178
Phosphorus mass (lbs)	67.569
COD mass (lbs)	2630.487
Animal feedlot rating number	39

Cell # 92 000	
Nitrogen concentration (ppm)	11.341
Phosphorus concentration (ppm)	3.444
COD concentration (ppm)	144.802
Nitrogen mass (lbs)	93.003
Phosphorus mass (lbs)	28.243
COD mass (lbs)	1187.464
Animal feedlot rating number	30

Cell # 205 000	
Nitrogen concentration (ppm)	5.061
Phosphorus concentration (ppm)	0.867
COD concentration (ppm)	26.333
Nitrogen mass (lbs)	15.554
Phosphorus mass (lbs)	2.665
COD mass (lbs)	80.930
Animal feedlot rating number	0

Cell # 208 000	
Nitrogen concentration (ppm)	1.397
Phosphorus concentration (ppm)	0.513
COD concentration (ppm)	13.388
Nitrogen mass (lbs)	16.313
Phosphorus mass (lbs)	5.986
COD mass (lbs)	156.346
Animal feedlot rating number	1

Cell # 238 000	
Nitrogen concentration (ppm)	3.261
Phosphorus concentration (ppm)	0.647
COD concentration (ppm)	39.335
Nitrogen mass (lbs)	11.202
Phosphorus mass (lbs)	2.222
COD mass (lbs)	135.122
Animal feedlot rating number	0

Cell # 240 000	
Nitrogen concentration (ppm)	7.677
Phosphorus concentration (ppm)	1.536
COD concentration (ppm)	68.379
Nitrogen mass (lbs)	17.835
Phosphorus mass (lbs)	3.569
COD mass (lbs)	158.849
Animal feedlot rating number	5

Feedlot Analysis (1 Year Event)

Cell # 257 000	
Nitrogen concentration (ppm)	2.698
Phosphorus concentration (ppm)	0.597
COD concentration (ppm)	32.198
Nitrogen mass (lbs)	33.374
Phosphorus mass (lbs)	7.380
COD mass (lbs)	398.300
Animal feedlot rating number	11

Cell # 283 000	
Nitrogen concentration (ppm)	4.281
Phosphorus concentration (ppm)	1.438
COD concentration (ppm)	131.445
Nitrogen mass (lbs)	30.067
Phosphorus mass (lbs)	10.102
COD mass (lbs)	923.149
Animal feedlot rating number	29

Cell # 287 000	
Nitrogen concentration (ppm)	11.233
Phosphorus concentration (ppm)	1.978
COD concentration (ppm)	61.963
Nitrogen mass (lbs)	226.214
Phosphorus mass (lbs)	39.837
COD mass (lbs)	1247.823
Animal feedlot rating number	4

Cell # 309 000	
Nitrogen concentration (ppm)	9.201
Phosphorus concentration (ppm)	2.122
COD concentration (ppm)	62.599
Nitrogen mass (lbs)	545.516
Phosphorus mass (lbs)	125.834
COD mass (lbs)	3711.607
Animal feedlot rating number	35

Cell # 322 000	
Nitrogen concentration (ppm)	12.405
Phosphorus concentration (ppm)	5.019
COD concentration (ppm)	230.145
Nitrogen mass (lbs)	42.434
Phosphorus mass (lbs)	17.168
COD mass (lbs)	787.285
Animal feedlot rating number	27

Cell # 332 000	
Nitrogen concentration (ppm)	13.794
Phosphorus concentration (ppm)	2.969
COD concentration (ppm)	177.264
Nitrogen mass (lbs)	872.921
Phosphorus mass (lbs)	187.894
COD mass (lbs)	11218.060
Animal feedlot rating number	67

Feedlot Analysis (1 Year Event)

Cell # 335 000	
Nitrogen concentration (ppm)	2.516
Phosphorus concentration (ppm)	0.652
COD concentration (ppm)	45.757
Nitrogen mass (lbs)	15.730
Phosphorus mass (lbs)	4.075
COD mass (lbs)	286.060
Animal feedlot rating number	11

Cell # 385 000	
Nitrogen concentration (ppm)	17.851
Phosphorus concentration (ppm)	6.269
COD concentration (ppm)	275.635
Nitrogen mass (lbs)	56.364
Phosphorus mass (lbs)	19.793
COD mass (lbs)	870.307
Animal feedlot rating number	27

Cell # 387 000	
Nitrogen concentration (ppm)	8.304
Phosphorus concentration (ppm)	3.065
COD concentration (ppm)	127.954
Nitrogen mass (lbs)	141.495
Phosphorus mass (lbs)	52.235
COD mass (lbs)	2180.298
Animal feedlot rating number	42

Cell # 391 000	
Nitrogen concentration (ppm)	12.350
Phosphorus concentration (ppm)	4.419
COD concentration (ppm)	194.393
Nitrogen mass (lbs)	90.503
Phosphorus mass (lbs)	32.380
COD mass (lbs)	1424.558
Animal feedlot rating number	34

Cell # 417 000	
Nitrogen concentration (ppm)	4.383
Phosphorus concentration (ppm)	0.761
COD concentration (ppm)	50.063
Nitrogen mass (lbs)	17.319
Phosphorus mass (lbs)	3.009
COD mass (lbs)	197.837
Animal feedlot rating number	4

Sediment Analysis at the Outlet (Cell 103, 1 Year Event)

Particle type	Area Weighted Erosion Upland (t/a)	Area Weighted Erosion Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Conc. (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.09	0.00	17	2	154.58	0.02	268.24
SILT	0.01	0.00	1	0	0.88	0.00	1.52
SAGG	0.07	0.00	0	0	1.09	0.00	1.89
LAGG	0.04	0.00	1	0	3.68	0.00	6.39
SAND	0.01	0.00	1	0	1.15	0.00	2.00
TOTAL	0.22	0.00	8	1	161.38	0.02	280.04

Hydrology of Each Subwatershed (1 Year Event)

-HYDR- Cell Num Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
78 000	720.00	0.58	1.01	326.41	0.99	318.51
95 000	1720.00	0.00	0.73	441.71	0.71	419.52
103 000	17000.00	0.87	0.90	1645.40	0.90	1631.45
143 000	1240.00	0.00	0.72	297.88	0.70	285.72
150 000	680.00	0.87	0.84	230.67	0.84	231.61
151 000	720.00	0.87	0.83	168.71	0.83	170.89
162 000	960.00	0.00	0.66	252.85	0.64	243.05
170 000	680.00	0.00	0.59	180.61	0.56	167.73
201 000	1800.00	0.54	0.66	370.75	0.66	367.99
225 000	520.00	0.54	0.50	123.51	0.51	123.39
248 000	920.00	0.87	0.60	127.72	0.61	130.81
268 000	440.00	0.01	0.57	90.73	0.52	82.09
300 000	2760.00	0.25	0.61	514.61	0.61	507.68

Sediment Analysis of Each Subwatershed (1 Year Event)

-SED- Cell Num Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
78 000	CLAY	0.00	4.81	0.00	4.77	1
	SILT	0.00	4.45	0.00	3.63	18
	SAGG	0.00	6.13	0.00	2.16	65
	LAGG	0.00	1.11	0.00	0.04	97
	SAND	0.00	0.32	0.00	0.01	96
	TOTL	0.00	16.82	0.00	10.61	37
95 000	CLAY	0.00	169.98	0.02	169.43	0
	SILT	0.00	10.21	0.04	9.48	7
	SAGG	0.01	17.23	0.23	11.95	32
	LAGG	0.00	4.55	0.15	6.09	-23
	SAND	0.00	1.82	0.03	1.67	10
	TOTL	0.01	203.81	0.47	198.63	3

103 000	CLAY	0.00	299.43	0.00	268.24	10
	SILT	0.00	1.50	0.00	1.52	-1
	SAGG	0.00	1.86	0.00	1.89	-2
	LAGG	0.00	6.26	0.00	6.39	-2
	SAND	0.00	1.96	0.00	2.00	-2
	TOTL	0.00	311.02	0.00	280.04	10
143 000	CLAY	0.00	76.32	0.02	76.04	0
	SILT	0.00	7.17	0.03	6.62	8
	SAGG	0.01	13.50	0.21	9.00	34
	LAGG	0.00	7.67	0.13	6.24	20
	SAND	0.00	2.37	0.02	1.96	18
	TOTL	0.01	107.04	0.41	99.85	7
150 000	CLAY	0.03	34.56	1.31	35.70	0
	SILT	0.05	5.76	2.09	7.10	10
	SAGG	0.33	3.99	13.05	12.46	27
	LAGG	0.20	0.30	8.09	4.44	47
	SAND	0.04	0.08	1.57	1.33	19
	TOTL	0.65	44.70	26.10	61.02	14
151 000	CLAY	0.00	12.30	0.00	8.93	27
	SILT	0.00	12.32	0.00	0.18	99
	SAGG	0.00	33.82	0.00	0.22	99
	LAGG	0.00	3.37	0.00	0.74	78
	SAND	0.00	0.91	0.00	0.23	75
	TOTL	0.00	62.72	0.00	10.29	84
162 000	CLAY	0.00	166.21	0.02	165.77	0
	SILT	0.00	5.39	0.03	5.10	6
	SAGG	0.01	8.64	0.21	6.56	26
	LAGG	0.00	6.98	0.13	4.78	33
	SAND	0.00	2.43	0.02	1.50	39
	TOTL	0.01	189.65	0.41	183.71	3
170 000	CLAY	0.01	46.17	0.47	45.82	2
	SILT	0.00	5.06	0.00	3.76	26
	SAGG	0.00	13.85	0.00	2.49	82
	LAGG	0.00	0.98	0.00	0.17	83
	SAND	0.00	0.24	0.00	0.05	78
	TOTL	0.01	66.31	0.47	52.28	22
201 000	CLAY	0.57	389.90	22.79	411.33	0
	SILT	0.00	7.60	0.00	6.99	8
	SAGG	0.00	16.66	0.00	11.08	33
	LAGG	0.00	11.90	0.00	1.28	89
	SAND	0.00	3.78	0.00	0.40	89
	TOTL	0.57	429.83	22.79	431.08	5
225 000	CLAY	0.44	44.03	17.53	60.80	1
	SILT	0.00	0.10	0.00	0.08	21
	SAGG	0.00	0.12	0.00	0.04	63
	LAGG	0.00	0.41	0.00	0.13	67
	SAND	0.00	0.13	0.00	0.04	67
	TOTL	0.44	44.78	17.53	61.10	2
248 000	CLAY	0.00	153.31	0.00	87.86	43
	SILT	0.00	2.59	0.00	0.19	93
	SAGG	0.00	0.73	0.00	0.23	68
	LAGG	0.00	0.03	0.00	1.55	-98
	SAND	0.00	0.01	0.00	0.49	-98
	TOTL	0.00	156.68	0.00	90.32	42

268 000	CLAY	0.00	69.89	0.00	66.92	4
	SILT	0.00	2.62	0.00	0.77	71
	SAGG	0.00	10.56	0.00	0.01	100
	LAGG	0.00	1.38	0.00	0.04	97
	SAND	0.00	0.37	0.00	0.01	97
	TOTL	0.00	84.82	0.00	67.76	20
300 000	CLAY	0.04	206.54	1.77	207.82	0
	SILT	0.00	13.05	0.00	12.28	6
	SAGG	0.00	11.16	0.00	8.38	25
	LAGG	0.00	11.29	0.00	1.32	88
	SAND	0.00	3.73	0.00	0.41	89
	TOTL	0.04	245.78	1.77	230.21	7

Condensed Soil Loss (1 Year Event)

			----- RUNOFF ------			----------- SEDIMENT ---------------				
Cell Num	Div	Drainage Area (acres)	Vol. (in.)	Generated Above (%)	Peak Rate (cfs)	Cell Erosion (t/a)	Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
78	000	720.00	0.58	96.7	318.51	0.00	16.82	0.00	10.61	37
95	000	1720.00	0.00	100.0	419.52	0.01	203.81	0.47	198.63	3
103	000	17000.00	0.87	99.8	1631.45	0.00	311.02	0.00	280.04	10
143	000	1240.00	0.00	100.0	285.72	0.01	107.04	0.41	99.85	7
150	000	680.00	0.87	93.9	231.61	0.65	44.70	26.10	61.02	14
151	000	720.00	0.87	94.2	170.89	0.00	62.72	0.00	10.29	84
162	000	960.00	0.00	100.0	243.05	0.01	189.65	0.41	183.71	3
170	000	680.00	0.00	100.0	167.73	0.01	66.31	0.47	52.28	22
201	000	1800.00	0.54	98.2	367.99	0.57	429.83	22.79	431.08	5
225	000	520.00	0.54	91.8	123.39	0.44	44.78	17.53	61.10	2
248	000	920.00	0.87	93.8	130.81	0.00	156.68	0.00	90.32	42
268	000	440.00	0.01	99.9	82.09	0.00	84.82	0.00	67.76	20
300	000	2760.00	0.25	99.4	507.68	0.04	245.78	1.77	230.21	7

Nutrient Analysis (1 Year Event)
N I T R O G E N

			---- Sediment ----		----- Water Soluble ------		
Cell Num	Div	Drainage Area (acres)	Within Cell (lbs/a)	Cell Outlet (lbs/a)	Within Cell (lbs/a)	Cell Outlet (lbs/a)	Conc (ppm)
78	000	720.00	0.10	0.12	0.38	2.77	12.38
95	000	1720.00	0.09	0.56	0.12	3.93	24.38
103	000	17000.00	0.00	0.14	0.38	2.71	13.27
143	000	1240.00	0.08	0.42	0.29	2.42	15.34
150	000	680.00	2.25	0.46	5.58	6.10	32.08
151	000	720.00	0.00	0.12	0.38	4.58	24.22
162	000	960.00	0.08	0.84	0.12	3.60	24.95
170	000	680.00	0.14	0.61	0.05	1.94	15.28
201	000	1800.00	3.03	1.51	2.60	4.26	28.50
225	000	520.00	2.45	0.86	2.60	2.51	21.96
248	000	920.00	0.00	0.57	0.38	3.12	22.52
268	000	440.00	0.00	0.81	0.38	1.11	9.44
300	000	2760.00	0.39	0.65	0.05	2.83	20.50

Nutrient Analysis (1 Year Event)
P H O S P H O R U S

Cell Num	Div	Drainage Area (acres)	Sediment Within Cell (lbs/a)	Sediment Cell Outlet (lbs/a)	Water Soluble Within Cell (lbs/a)	Water Soluble Cell Outlet (lbs/a)	Water Soluble Conc (ppm)
78	000	720.00	0.05	0.06	0.01	0.60	2.68
95	000	1720.00	0.05	0.28	0.01	0.81	5.05
103	000	17000.00	0.00	0.07	0.00	0.60	2.93
143	000	1240.00	0.04	0.21	0.02	0.48	3.06
150	000	680.00	1.12	0.23	1.15	1.27	6.68
151	000	720.00	0.00	0.06	1.02	1.01	5.33
162	000	960.00	0.04	0.42	0.01	0.73	5.03
170	000	680.00	0.07	0.30	0.00	0.39	3.05
201	000	1800.00	1.51	0.76	0.52	0.88	5.90
225	000	520.00	1.23	0.43	0.52	0.56	4.88
248	000	920.00	0.00	0.28	0.00	0.64	4.65
268	000	440.00	0.00	0.41	0.01	0.20	1.73
300	000	2760.00	0.20	0.33	0.00	0.60	4.31

Nutrient Analysis (1 Year Event)
Chemical Oxygen Demand

Cell Num	Div	Drainage Area (acres)	Sediment Within Cell (lbs/a)	Sediment Cell Outlet (lbs/a)	Water Soluble Within Cell (lbs/a)	Water Soluble Cell Outlet (lbs/a)	Water Soluble Conc (ppm)
78	000	720.00			8.00	28.50	127.30
95	000	1720.00			8.00	23.95	148.69
103	000	17000.00			0.00	18.04	88.37
143	000	1240.00			24.00	20.09	127.04
150	000	680.00			33.00	32.21	169.37
151	000	720.00			0.00	31.31	165.73
162	000	960.00			8.00	25.51	176.94
170	000	680.00			3.00	12.77	100.81
201	000	1800.00			21.00	29.17	195.05
225	000	520.00			21.00	19.73	172.38
248	000	920.00			0.00	18.81	135.95
268	000	440.00			0.00	10.74	91.45
300	000	2760.00			3.00	16.77	121.59

PELICAN LAKE WATERSHED SUMMARY (5 YEAR EVENT)

Watershed Summary

Watershed Studied	LAKE PELICAN WATERSHED
The area of the watershed is	17000.00 acres
The area of each cell is	40.00 acres
Type of event modeled	**5 year, 24 hour**
The characteristic storm precipitation is	3.30 inches
The storm energy-intensity value is	64.90

Values at the Watershed Outlet (Cell 103)

Cell number	103 000
Runoff volume	1.79 inches
Peak runoff rate	3177.27 cfs
Total Nitrogen in sediment	0.44 lbs/acre
Total soluble Nitrogen in runoff	4.06 lbs/acre
Soluble Nitrogen concentration in runoff	9.99 ppm
Total Phosphorus in sediment	0.22 lbs/acre
Total soluble Phosphorus in runoff	0.93 lbs/acre
Soluble Phosphorus concentration in runoff	2.28 ppm
Total soluble Chemical Oxygen Demand in runoff	39.18 lbs/acre
Soluble Chemical Oxygen Demand concentration in runoff	96.45 ppm

Sediment Analysis at the Outlet (Cell 103, 5 Year Event)

Particle type	Area Weighted Erosion Upland (t/a)	Area Weighted Erosion Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Conc. (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.25	0.00	29	2	349.72	0.07	1207.65
SILT	0.03	0.00	0	0	0.63	0.00	2.18
SAGG	0.18	0.00	0	0	0.78	0.00	2.71
LAGG	0.10	0.01	0	0	2.65	0.00	9.16
SAND	0.02	0.00	1	0	0.83	0.00	2.87
TOTAL	0.58	0.00	12	1	354.61	0.07	1224.56

Hydrology of Each Subwatershed (5 Year Event)

-HYDR- Cell Num	Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
78	000	720.00	1.41	2.02	616.59	1.99	605.91
95	000	1720.00	0.01	1.62	930.95	1.58	884.39
103	000	17000.00	1.84	1.79	3203.91	1.79	3177.27
143	000	1240.00	0.01	1.59	619.77	1.54	594.65
150	000	680.00	1.84	1.74	451.60	1.75	454.26
151	000	720.00	1.84	1.78	339.84	1.79	344.26
162	000	960.00	0.01	1.50	536.39	1.44	515.82
170	000	680.00	0.00	1.40	396.36	1.32	368.32
201	000	1800.00	1.35	1.49	789.17	1.49	784.94
225	000	520.00	1.35	1.23	280.21	1.24	280.53
248	000	920.00	1.84	1.40	279.48	1.42	284.88
268	000	440.00	0.01	1.38	203.60	1.26	184.36
300	000	2760.00	0.84	1.42	1133.37	1.41	1120.99

Sediment Analysis of Each Subwatershed (5 Year Event)

-SED- Cell Num	Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
78	000	CLAY	0.00	12.78	0.00	12.72	1
		SILT	0.00	14.05	0.00	12.26	13
		SAGG	0.00	27.01	0.00	13.82	49
		LAGG	0.00	2.03	0.00	0.06	97
		SAND	0.00	0.53	0.00	0.02	97
		TOTL	0.00	56.41	0.00	38.87	31
95	000	CLAY	0.00	459.61	0.06	458.66	0
		SILT	0.00	33.03	0.10	31.40	5
		SAGG	0.02	71.19	0.63	55.60	23
		LAGG	0.01	8.09	0.39	8.54	-1
		SAND	0.00	4.16	0.08	2.57	39
		TOTL	0.03	576.07	1.25	556.78	4
103	000	CLAY	0.00	1298.81	0.00	1207.65	7
		SILT	0.00	2.16	0.00	2.18	-1
		SAGG	0.00	2.66	0.00	2.71	-2
		LAGG	0.00	8.97	0.00	9.16	-2
		SAND	0.00	2.81	0.00	2.87	-2
		TOTL	0.00	1315.42	0.00	1224.56	7
143	000	CLAY	0.00	205.78	0.06	205.27	0
		SILT	0.00	23.07	0.09	21.78	6
		SAGG	0.01	49.36	0.55	37.07	26
		LAGG	0.01	12.44	0.34	9.59	25
		SAND	0.00	3.73	0.07	3.01	21
		TOTL	0.03	294.37	1.10	276.72	6
150	000	CLAY	0.09	93.07	3.49	96.25	0
		SILT	0.14	20.89	5.58	24.63	7
		SAGG	0.87	21.82	34.86	43.97	22
		LAGG	0.54	0.71	21.61	7.63	66
		SAND	0.10	0.15	4.18	2.11	51
		TOTL	1.74	136.64	69.72	174.59	15

151 000	CLAY	0.00	32.91	0.00	26.74	19
	SILT	0.00	37.89	0.00	0.27	99
	SAGG	0.00	114.34	0.00	0.33	100
	LAGG	0.00	7.73	0.00	1.12	86
	SAND	0.00	1.69	0.00	0.35	79
	TOTL	0.00	194.56	0.00	28.82	85
162 000	CLAY	0.00	443.49	0.06	442.74	0
	SILT	0.00	16.66	0.09	16.01	4
	SAGG	0.01	36.90	0.55	30.29	19
	LAGG	0.01	10.20	0.34	7.45	29
	SAND	0.00	4.08	0.07	2.33	44
	TOTL	0.03	511.34	1.10	498.83	3
170 000	CLAY	0.03	124.13	1.25	123.56	1
	SILT	0.00	15.64	0.00	13.03	17
	SAGG	0.00	48.60	0.00	19.35	60
	LAGG	0.00	2.66	0.00	0.27	90
	SAND	0.00	0.53	0.00	0.08	84
	TOTL	0.03	191.57	1.25	156.28	19
201 000	CLAY	1.52	1048.72	60.86	1107.31	0
	SILT	0.00	23.19	0.00	21.99	5
	SAGG	0.00	68.22	0.00	52.77	23
	LAGG	0.00	18.12	0.00	1.98	89
	SAND	0.00	5.80	0.00	0.62	89
	TOTL	1.52	1164.05	60.86	1184.67	3
225 000	CLAY	1.17	163.42	46.82	208.62	1
	SILT	0.00	0.16	0.00	0.14	14
	SAGG	0.00	0.20	0.00	0.11	47
	LAGG	0.00	0.67	0.00	0.22	67
	SAND	0.00	0.21	0.00	0.07	67
	TOTL.	1.17	164.65	46.82	209.15	1
248 000	CLAY	0.00	416.90	0.00	297.92	29
	SILT	0.00	10.02	0.00	0.30	97
	SAGG	0.00	9.29	0.00	0.37	96
	LAGG	0.00	0.05	0.00	2.45	-98
	SAND	0.00	0.02	0.00	0.77	-98
	TOTL	0.00	436.28	0.00	301.81	31
268 000	CLAY	0.00	187.96	0.00	183.09	3
	SILT	0.00	7.26	0.00	3.64	50
	SAGG	0.00	33.01	0.00	0.02	100
	LAGG	0.00	3.12	0.00	0.07	98
	SAND	0.00	0.73	0.00	0.02	97
	TOTL	0.00	232.07	0.00	186.84	19
300 000	CLAY	0.12	560.76	4.73	564.67	0
	SILT	0.00	49.77	0.00	47.93	4
	SAGG	0.00	54.06	0.00	45.20	16
	LAGG	0.00	15.95	0.00	2.07	87
	SAND	0.00	5.40	0.00	0.65	88
	TOTL	0.12	685.94	4.73	660.51	4

Condensed Soil Loss (5 Year Event)

Cell Num	Div	Drainage Area (acres)	RUNOFF Vol. (in.)	RUNOFF Generated Above (%)	RUNOFF Peak Rate (cfs)	SEDIMENT Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	SEDIMENT Generated Within (tons)	SEDIMENT Yield (tons)	SEDIMENT Depo (%)
78	000	720.00	1.41	96.1	605.91	0.00	56.41	0.00	38.87	31
95	000	1720.00	0.01	100.0	884.39	0.03	576.07	1.25	556.78	4
103	000	17000.00	1.84	99.8	3177.27	0.00	1315.42	0.00	1224.56	7
143	000	1240.00	0.01	100.0	594.65	0.03	294.37	1.10	276.72	6
150	000	680.00	1.84	93.8	454.26	1.74	136.64	69.72	174.59	15
151	000	720.00	1.84	94.3	344.26	0.00	194.56	0.00	28.82	85
162	000	960.00	0.01	100.0	515.82	0.03	511.34	1.10	498.83	3
170	000	680.00	0.00	100.0	368.32	0.03	191.57	1.25	156.28	19
201	000	1800.00	1.35	98.0	784.94	1.52	1164.05	60.86	1184.67	3
225	000	520.00	1.35	91.6	280.53	1.17	164.65	46.82	209.15	1
248	000	920.00	1.84	94.4	284.88	0.00	436.28	0.00	301.81	31
268	000	440.00	0.01	99.9	184.36	0.00	232.07	0.00	186.84	19
300	000	2760.00	0.84	99.1	1120.99	0.12	685.94	4.73	660.51	4

Nutrient Analysis (5 Year Event)
N I T R O G E N

Cell Num	Div	Drainage Area (acres)	Sediment Within Cell (lbs/a)	Sediment Cell Outlet (lbs/a)	Water Soluble Within Cell (lbs/a)	Water Soluble Cell Outlet (lbs/a)	Water Soluble Conc (ppm)
78	000	720.00	0.23	0.35	0.60	4.02	8.92
95	000	1720.00	0.20	1.28	0.28	5.78	16.13
103	000	17000.00	0.00	0.44	0.60	4.06	9.99
143	000	1240.00	0.18	0.95	0.51	3.53	10.13
150	000	680.00	4.93	1.07	8.07	8.79	22.19
151	000	720.00	0.00	0.28	0.60	6.85	16.92
162	000	960.00	0.18	1.87	0.28	5.53	16.99
170	000	680.00	0.30	1.46	0.16	2.85	9.55
201	000	1800.00	6.64	3.40	3.84	6.46	19.18
225	000	520.00	5.38	2.29	3.84	4.60	16.36
248	000	920.00	0.00	1.49	0.60	4.64	14.43
268	000	440.00	0.00	1.83	0.60	1.68	5.90
300	000	2760.00	0.86	1.51	0.16	4.18	13.06

Nutrient Analysis (5 Year Event)
P H O S P H O R U S

Cell Num	Div	Drainage Area (acres)	---- Sediment ---- Within Cell (lbs/a)	Cell Outlet (lbs/a)	----- Water Soluble ------ Within Cell (lbs/a)	Cell Outlet (lbs/a)	Conc (ppm)
78	000	720.00	0.11	0.18	0.01	0.88	1.95
95	000	1720.00	0.10	0.64	0.02	1.25	3.48
103	000	17000.00	0.00	0.22	0.01	0.93	2.28
143	000	1240.00	0.09	0.48	0.03	0.73	2.09
150	000	680.00	2.47	0.53	1.74	1.93	4.86
151	000	720.00	0.00	0.14	1.55	1.57	3.88
162	000	960.00	0.09	0.94	0.02	1.15	3.52
170	000	680.00	0.15	0.73	0.01	0.58	1.95
201	000	1800.00	3.32	1.70	0.79	1.39	4.13
225	000	520.00	2.69	1.15	0.79	1.02	3.64
248	000	920.00	0.00	0.75	0.01	1.00	3.11
268	000	440.00	0.00	0.92	0.01	0.31	1.09
300	000	2760.00	0.43	0.76	0.01	0.91	2.85

Nutrient Analysis (5 Year Event)
Chemical Oxygen Demand

Cell Num	Div	Drainage Area (acres)	---- Sediment ---- Within Cell (lbs/a)	Cell Outlet (lbs/a)	----- Water Soluble ------ Within Cell (lbs/a)	Cell Outlet (lbs/a)	Conc (ppm)
78	000	720.00			19.00	53.78	119.35
95	000	1720.00			19.00	51.90	144.83
103	000	17000.00			0.00	39.18	96.45
143	000	1240.00			44.00	43.94	126.10
150	000	680.00			71.00	66.63	168.26
151	000	720.00			0.00	66.83	165.09
162	000	960.00			19.00	58.57	179.87
170	000	680.00			11.00	29.95	100.41
201	000	1800.00			52.00	60.11	178.49
225	000	520.00			52.00	46.30	164.73
248	000	920.00			0.00	42.96	133.54
268	000	440.00			0.00	25.64	89.87
300	000	2760.00			11.00	37.99	118.57

PELICAN LAKE WATERSHED SUMMARY (25 YEAR EVENT)

Watershed Summary

Watershed Studied	LAKE PELICAN WATERSHED
The area of the watershed is	17000.00 acres
The area of each cell is	40.00 acres
Type of event modeled	**25 year, 24 hr.**
The characteristic storm precipitation is	4.40 inches
The storm energy-intensity value is	121.20

Values at the Watershed Outlet (Cell 103)

Cell number	103 000
Runoff volume	2.69 inches
Peak runoff rate	4712.58 cfs
Total Nitrogen in sediment	0.88 lbs/acre
Total soluble Nitrogen in runoff	4.95 lbs/acre
Soluble Nitrogen concentration in runoff	8.12 ppm
Total Phosphorus in sediment	0.44 lbs/acre
Total soluble Phosphorus in runoff	1.16 lbs/acre
Soluble Phosphorus concentration in runoff	1.90 ppm
Total soluble Chemical Oxygen Demand in runoff	60.79 lbs/acre
Soluble Chemical Oxygen Demand concentration in runoff	99.61 ppm

Feedlot Analysis (25 Year Event)

Cell #	9 000
Nitrogen concentration (ppm)	4.376
Phosphorus concentration (ppm)	0.759
COD concentration (ppm)	38.775
Nitrogen mass (lbs)	63.567
Phosphorus mass (lbs)	11.031
COD mass (lbs)	563.227
Animal feedlot rating number	15

Cell #	22 000
Nitrogen concentration (ppm)	4.991
Phosphorus concentration (ppm)	1.151
COD concentration (ppm)	38.245
Nitrogen mass (lbs)	307.894
Phosphorus mass (lbs)	70.986
COD mass (lbs)	2359.278
Animal feedlot rating number	31

Cell #	40 000
Nitrogen concentration (ppm)	11.097
Phosphorus concentration (ppm)	3.994
COD concentration (ppm)	170.814
Nitrogen mass (lbs)	312.718
Phosphorus mass (lbs)	112.552
COD mass (lbs)	4813.609
Animal feedlot rating number	54

Feedlot Analysis (25 Year Event)

Cell # 87 000	
Nitrogen concentration (ppm)	10.107
Phosphorus concentration (ppm)	2.450
COD concentration (ppm)	91.668
Nitrogen mass (lbs)	795.940
Phosphorus mass (lbs)	192.939
COD mass (lbs)	7219.232
Animal feedlot rating number	55

Cell # 92 000	
Nitrogen concentration (ppm)	9.500
Phosphorus concentration (ppm)	2.557
COD concentration (ppm)	100.607
Nitrogen mass (lbs)	259.880
Phosphorus mass (lbs)	69.936
COD mass (lbs)	2752.161
Animal feedlot rating number	42

Cell # 205 000	
Nitrogen concentration (ppm)	5.625
Phosphorus concentration (ppm)	0.959
COD concentration (ppm)	29.072
Nitrogen mass (lbs)	66.577
Phosphorus mass (lbs)	11.353
COD mass (lbs)	344.064
Animal feedlot rating number	0

Cell # 208 000	
Nitrogen concentration (ppm)	1.956
Phosphorus concentration (ppm)	0.615
COD concentration (ppm)	15.866
Nitrogen mass (lbs)	72.060
Phosphorus mass (lbs)	22.655
COD mass (lbs)	584.585
Animal feedlot rating number	14

Cell # 238 000	
Nitrogen concentration (ppm)	2.676
Phosphorus concentration (ppm)	0.556
COD concentration (ppm)	37.951
Nitrogen mass (lbs)	28.246
Phosphorus mass (lbs)	5.872
COD mass (lbs)	400.631
Animal feedlot rating number	13

Cell # 240 000	
Nitrogen concentration (ppm)	7.522
Phosphorus concentration (ppm)	1.525
COD concentration (ppm)	64.366
Nitrogen mass (lbs)	66.815
Phosphorus mass (lbs)	13.544
COD mass (lbs)	571.765
Animal feedlot rating number	22

Feedlot Analysis (25 Year Event)

Cell # 257 000	
Nitrogen concentration (ppm)	2.063
Phosphorus concentration (ppm)	0.452
COD concentration (ppm)	19.309
Nitrogen mass (lbs)	99.454
Phosphorus mass (lbs)	21.787
COD mass (lbs)	930.677
Animal feedlot rating number	18

Cell # 283 000	
Nitrogen concentration (ppm)	3.116
Phosphorus concentration (ppm)	0.989
COD concentration (ppm)	74.751
Nitrogen mass (lbs)	73.834
Phosphorus mass (lbs)	23.433
COD mass (lbs)	1771.059
Animal feedlot rating number	39

Cell # 287 000	
Nitrogen concentration (ppm)	11.457
Phosphorus concentration (ppm)	1.985
COD concentration (ppm)	61.389
Nitrogen mass (lbs)	949.779
Phosphorus mass (lbs)	164.514
COD mass (lbs)	5088.967
Animal feedlot rating number	21

Cell # 309 000	
Nitrogen concentration (ppm)	9.022
Phosphorus concentration (ppm)	2.020
COD concentration (ppm)	54.591
Nitrogen mass (lbs)	1981.234
Phosphorus mass (lbs)	443.703
COD mass (lbs)	11988.430
Animal feedlot rating number	39

Cell # 322 000	
Nitrogen concentration (ppm)	10.064
Phosphorus concentration (ppm)	3.508
COD concentration (ppm)	151.223
Nitrogen mass (lbs)	153.187
Phosphorus mass (lbs)	53.397
COD mass (lbs)	2301.856
Animal feedlot rating number	42

Cell # 332 000	
Nitrogen concentration (ppm)	10.106
Phosphorus concentration (ppm)	2.216
COD concentration (ppm)	92.273
Nitrogen mass (lbs)	2554.387
Phosphorus mass (lbs)	560.050
COD mass (lbs)	23322.640
Animal feedlot rating number	76

Feedlot Analysis (25 Year Event)

Cell # 335 000	
Nitrogen concentration (ppm)	3.126
Phosphorus concentration (ppm)	0.717
COD concentration (ppm)	33.703
Nitrogen mass (lbs)	81.128
Phosphorus mass (lbs)	18.601
COD mass (lbs)	874.644
Animal feedlot rating number	22

Cell # 385 000	
Nitrogen concentration (ppm)	17.840
Phosphorus concentration (ppm)	6.261
COD concentration (ppm)	275.233
Nitrogen mass (lbs)	192.140
Phosphorus mass (lbs)	67.427
COD mass (lbs)	2964.294
Animal feedlot rating number	45

Cell # 387 000	
Nitrogen concentration (ppm)	6.801
Phosphorus concentration (ppm)	2.153
COD concentration (ppm)	82.053
Nitrogen mass (lbs)	365.116
Phosphorus mass (lbs)	115.578
COD mass (lbs)	4404.751
Animal feedlot rating number	52

Cell # 391 000	
Nitrogen concentration (ppm)	11.858
Phosphorus concentration (ppm)	3.967
COD concentration (ppm)	170.733
Nitrogen mass (lbs)	333.121
Phosphorus mass (lbs)	111.451
COD mass (lbs)	4796.490
Animal feedlot rating number	54

Cell # 417 000	
Nitrogen concentration (ppm)	5.573
Phosphorus concentration (ppm)	1.003
COD concentration (ppm)	48.342
Nitrogen mass (lbs)	94.009
Phosphorus mass (lbs)	16.916
COD mass (lbs)	815.442
Animal feedlot rating number	20

Sediment Analysis at the Outlet (Cell 103, 25 Year Event)

Particle type	Area Weighted Erosion Upland (t/a)	Area Weighted Erosion Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Conc. (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.46	0.00	36	2	552.29	0.17	2865.09
SILT	0.05	0.00	0	0	0.53	0.00	2.77
SAGG	0.33	0.00	0	0	0.65	0.00	3.35
LAGG	0.19	0.01	0	0	2.18	0.00	11.33
SAND	0.04	0.00	0	0	0.68	0.00	3.55
TOTAL	1.08	0.00	16	1	556.33	0.17	2886.08

Hydrology of Each Subwatershed (25 Year Event)

-HYDR- Cell Num	Div	Drainage Area (acres)	Overland Runoff (in.)	Upstream Runoff (in.)	Peak Flow Upstream (cfs)	Downstream Runoff (in.)	Peak Flow Downstream (cfs)
78	000	720.00	2.29	3.02	890.19	2.98	877.87
95	000	1720.00	0.01	2.54	1415.02	2.48	1344.44
103	000	17000.00	2.82	2.69	4751.81	2.69	4712.58
143	000	1240.00	0.01	2.48	936.61	2.40	898.81
150	000	680.00	2.82	2.65	662.81	2.66	667.20
151	000	720.00	2.82	2.74	504.62	2.75	511.22
162	000	960.00	0.01	2.37	817.26	2.27	786.12
170	000	680.00	0.01	2.25	611.76	2.11	568.70
201	000	1800.00	2.21	2.35	1207.11	2.35	1201.74
225	000	520.00	2.21	2.01	439.02	2.03	439.90
248	000	920.00	2.82	2.24	431.65	2.27	439.08
268	000	440.00	0.01	2.25	317.08	2.05	287.27
300	000	2760.00	1.53	2.27	1756.36	2.26	1739.46

Sediment Analysis of Each Subwatershed (25 Year Event)

-SED- Cell Num	Div	Particle Type	Cell Erosion (t/a)	Generated Above (tons)	Generated Within (tons)	Yield (tons)	Deposition (%)
78	000	CLAY	0.00	23.84	0.00	23.74	0
		SILT	0.00	28.22	0.00	25.33	10
		SAGG	0.00	65.57	0.00	38.76	41
		LAGG	0.00	3.18	0.00	0.07	98
		SAND	0.00	0.76	0.00	0.02	97
		TOTL	0.00	121.57	0.00	87.92	28
95	000	CLAY	0.00	862.42	0.12	861.04	0
		SILT	0.00	67.29	0.19	64.66	4
		SAGG	0.03	170.03	1.17	140.09	18
		LAGG	0.02	12.10	0.73	10.47	18
		SAND	0.00	7.61	0.14	3.28	58
		TOTL	0.06	1119.45	2.34	1079.54	4

103 000	CLAY	0.00	3032.92	0.00	2865.09	6
	SILT	0.00	3.17	0.00	2.77	13
	SAGG	0.00	3.30	0.00	3.35	-2
	LAGG	0.00	11.10	0.00	11.33	-2
	SAND	0.00	3.48	0.00	3.55	-2
	TOTL	0.00	3053.96	0.00	2886.08	5
143 000	CLAY	0.00	385.66	0.10	384.93	0
	SILT	0.00	47.04	0.16	44.91	5
	SAGG	0.03	113.78	1.03	90.59	21
	LAGG	0.02	16.99	0.64	12.22	31
	SAND	0.00	4.91	0.12	3.83	24
	TOTL	0.05	568.39	2.06	536.48	6
150 000	CLAY	0.16	174.48	6.51	180.54	0
	SILT	0.26	44.74	10.42	52.03	6
	SAGG	1.63	62.51	65.10	102.19	20
	LAGG	1.01	1.33	40.36	11.47	72
	SAND	0.20	0.25	7.81	2.91	64
	TOTL	3.25	283.32	130.20	349.14	16
151 000	CLAY	0.00	61.51	0.00	52.30	15
	SILT	0.00	75.42	0.00	0.34	100
	SAGG	0.00	242.67	0.00	0.42	100
	LAGG	0.00	14.48	0.00	1.42	90
	SAND	0.00	2.79	0.00	0.44	84
	TOTL	0.00	396.86	0.00	54.92	86
162 000	CLAY	0.00	825.49	0.10	824.41	0
	SILT	0.00	33.21	0.16	32.17	4
	SAGG	0.03	87.06	1.03	74.43	16
	LAGG	0.02	12.52	0.64	9.56	27
	SAND	0.00	5.92	0.12	2.99	50
	TOTL	0.05	964.20	2.06	943.56	2
170 000	CLAY	0.06	232.18	2.34	231.21	1
	SILT	0.00	31.06	0.00	27.01	13
	SAGG	0.00	105.23	0.00	53.07	50
	LAGG	0.00	5.39	0.00	0.35	94
	SAND	0.00	0.97	0.00	0.11	89
	TOTL	0.06	374.84	2.34	311.74	17
201 000	CLAY	2.84	1959.45	113.66	2069.86	0
	SILT	0.00	46.24	0.00	44.38	4
	SAGG	0.00	160.97	0.00	132.14	18
	LAGG	0.00	23.34	0.00	2.54	89
	SAND	0.00	7.38	0.00	0.80	89
	TOTL	2.84	2197.38	113.66	2249.71	3
225 000	CLAY	2.19	341.35	87.43	426.25	1
	SILT	0.00	0.21	0.00	0.19	11
	SAGG	0.00	0.26	0.00	0.16	39
	LAGG	0.00	0.87	0.00	0.29	67
	SAND	0.00	0.27	0.00	0.09	67
	TOTL	2.19	342.96	87.43	426.98	1
248 000	CLAY	0.00	783.87	0.00	607.34	23
	SILT	0.00	22.00	0.00	0.39	98
	SAGG	0.00	28.13	0.00	0.48	98
	LAGG	0.00	0.07	0.00	3.17	-98
	SAND	0.00	0.02	0.00	0.99	-98
	TOTL	0.00	834.09	0.00	612.37	27
268 000	CLAY	0.00	351.86	0.00	344.94	2
	SILT	0.00	13.76	0.00	8.20	40
	SAGG	0.00	66.22	0.00	0.03	100
	LAGG	0.00	5.72	0.00	0.09	98
	SAND	0.00	1.16	0.00	0.03	98
	TOTL	0.00	438.74	0.00	353.28	19

300 000	CLAY	0.22	1053.00	8.84	1060.65	0
	SILT	0.00	108.30	0.00	105.23	3
	SAGG	0.00	145.61	0.00	126.98	13
	LAGG	0.00	18.96	0.00	2.66	86
	SAND	0.00	6.52	0.00	0.83	87
	TOTL	0.22	1332.39	8.84	1296.36	3

Condensed Soil Loss (25 Year Event)

Cell Num	Div	Drainage Area (acres)	RUNOFF Vol. (in.)	RUNOFF Generated Above (%)	RUNOFF Peak Rate (cfs)	SEDIMENT Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	SEDIMENT Generated Within (tons)	SEDIMENT Yield (tons)	SEDIMENT Depo (%)
78	000	720.00	2.29	95.7	877.87	0.00	121.57	0.00	87.92	28
95	000	1720.00	0.01	100.0	1344.44	0.06	1119.45	2.34	1079.54	4
103	000	17000.00	2.82	99.8	4712.58	0.00	3053.96	0.00	2886.08	5
143	000	1240.00	0.01	100.0	898.81	0.05	568.39	2.06	536.48	6
150	000	680.00	2.82	93.8	667.20	3.25	283.32	130.20	349.14	16
151	000	720.00	2.82	94.3	511.22	0.00	396.86	0.00	54.92	86
162	000	960.00	0.01	100.0	786.12	0.05	964.20	2.06	943.56	2
170	000	680.00	0.01	100.0	568.70	0.06	374.84	2.34	311.74	17
201	000	1800.00	2.21	97.9	1201.74	2.84	2197.38	113.66	2249.71	3
225	000	520.00	2.21	91.6	439.90	2.19	342.96	87.43	426.98	1
248	000	920.00	2.82	94.6	439.08	0.00	834.09	0.00	612.37	27
268	000	440.00	0.01	100.0	287.27	0.00	438.74	0.00	353.28	19
300	000	2760.00	1.53	99.0	1739.46	0.22	1332.39	8.84	1296.36	3

Nutrient Analysis (25 Year Event)
N I T R O G E N

Cell Num	Div	Drainage Area (acres)	Sediment Within Cell (lbs/a)	Sediment Cell Outlet (lbs/a)	Water Soluble Within Cell (lbs/a)	Water Soluble Cell Outlet (lbs/a)	Water Soluble Conc (ppm)
78	000	720.00	0.38	0.68	0.80	4.84	7.18
95	000	1720.00	0.33	2.18	0.44	6.94	12.35
103	000	17000.00	0.00	0.88	0.80	4.95	8.12
143	000	1240.00	0.29	1.62	0.71	4.20	7.72
150	000	680.00	8.13	1.86	9.57	10.45	17.37
151	000	720.00	0.00	0.46	0.80	8.34	13.40
162	000	960.00	0.29	3.12	0.44	6.86	13.35
170	000	680.00	0.49	2.54	0.30	3.41	7.12
201	000	1800.00	10.94	5.67	4.49	7.99	15.04
225	000	520.00	8.87	4.05	4.49	6.43	13.99
248	000	920.00	0.00	2.63	0.80	5.58	10.85
268	000	440.00	0.00	3.05	0.80	2.06	4.44
300	000	2760.00	1.42	2.59	0.30	5.02	9.82

Nutrient Analysis (25 Year Event)
P H O S P H O R U S

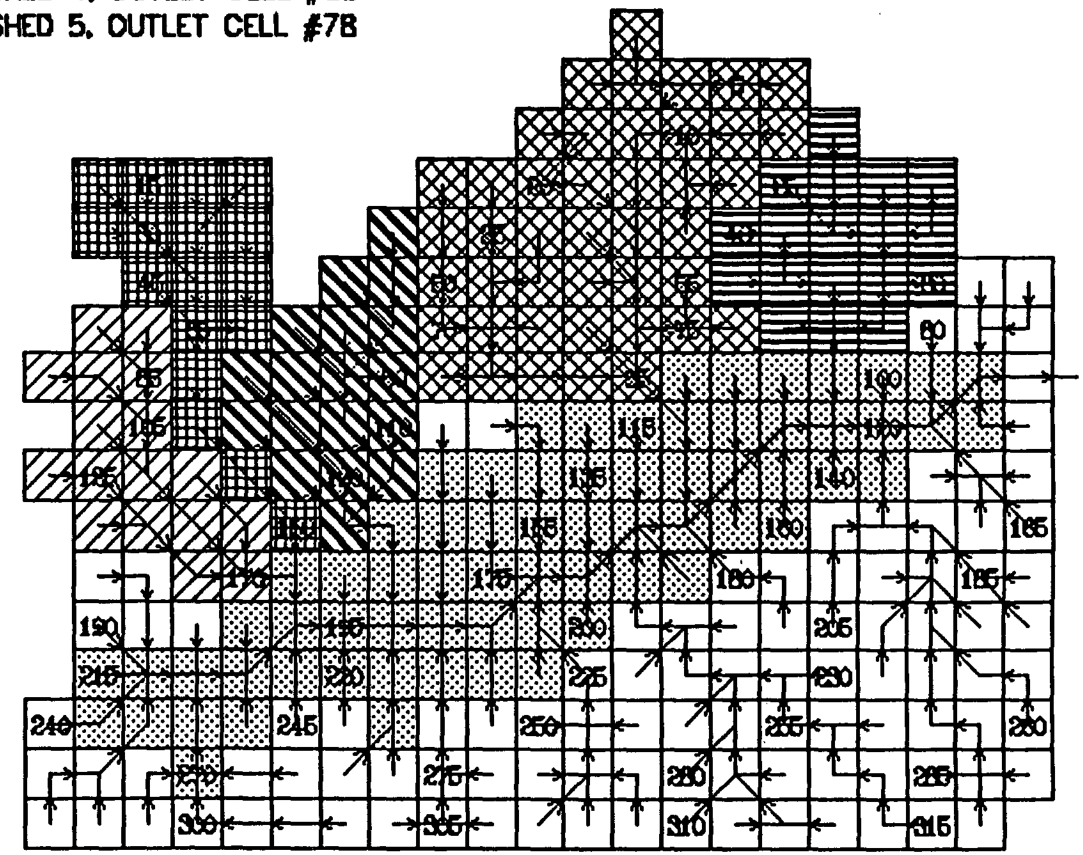
Cell Num	Div	Drainage Area (acres)	Sediment: Within Cell (lbs/a)	Sediment: Cell Outlet (lbs/a)	Water Soluble: Within Cell (lbs/a)	Water Soluble: Cell Outlet (lbs/a)	Water Soluble: Conc (ppm)
78	000	720.00	0.19	0.34	0.02	1.08	1.60
95	000	1720.00	0.16	1.09	0.03	1.55	2.76
103	000	17000.00	0.00	0.44	0.01	1.16	1.90
143	000	1240.00	0.15	0.81	0.04	0.89	1.64
150	000	680.00	4.07	0.93	2.15	2.40	3.99
151	000	720.00	0.00	0.23	1.92	1.97	3.16
162	000	960.00	0.15	1.56	0.03	1.45	2.83
170	000	680.00	0.25	1.27	0.02	0.71	1.49
201	000	1800.00	5.47	2.84	0.94	1.78	3.35
225	000	520.00	4.44	2.03	0.94	1.43	3.12
248	000	920.00	0.00	1.31	0.01	1.25	2.43
268	000	440.00	0.00	1.53	0.02	0.38	0.83
300	000	2760.00	0.71	1.30	0.02	1.13	2.20

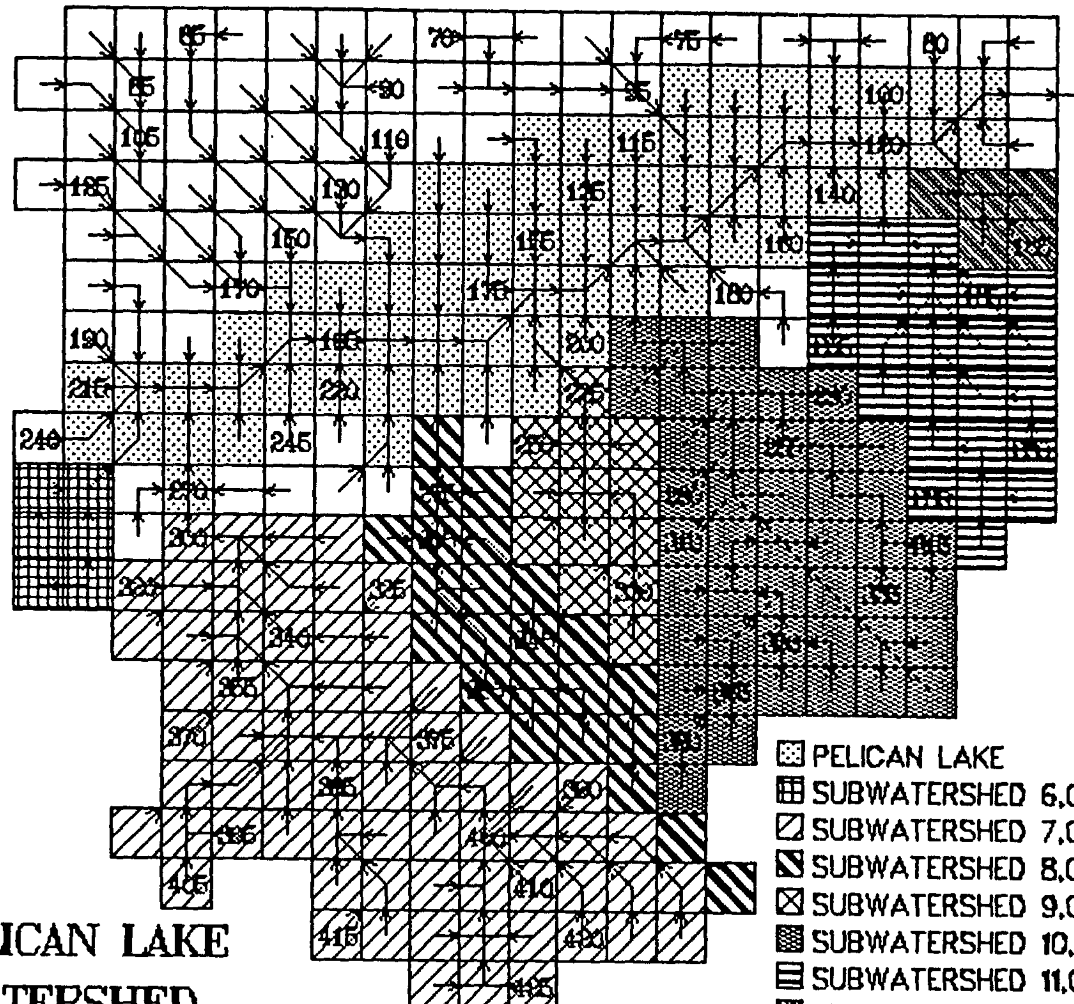
Nutrient Analysis (25 Year Event)
Chemical Oxygen Demand

Cell Num	Div	Drainage Area (acres)	Sediment: Within Cell (lbs/a)	Sediment: Cell Outlet (lbs/a)	Water Soluble: Within Cell (lbs/a)	Water Soluble: Cell Outlet (lbs/a)	Water Soluble: Conc (ppm)
78	000	720.00			31.00	78.82	116.85
95	000	1720.00			31.00	80.03	142.51
103	000	17000.00			0.00	60.79	99.61
143	000	1240.00			64.00	68.35	125.63
150	000	680.00			109.00	100.95	167.72
151	000	720.00			0.00	101.52	163.09
162	000	960.00			31.00	93.10	181.17
170	000	680.00			21.00	48.02	100.30
201	000	1800.00			85.00	91.88	172.84
225	000	520.00			85.00	74.64	162.36
248	000	920.00			0.00	67.83	131.95
268	000	440.00			0.00	41.40	89.20
300	000	2760.00			21.00	59.76	116.85

PELICAN LAKE WATERSHED (NORTHERN SUBWATERSHEDS)

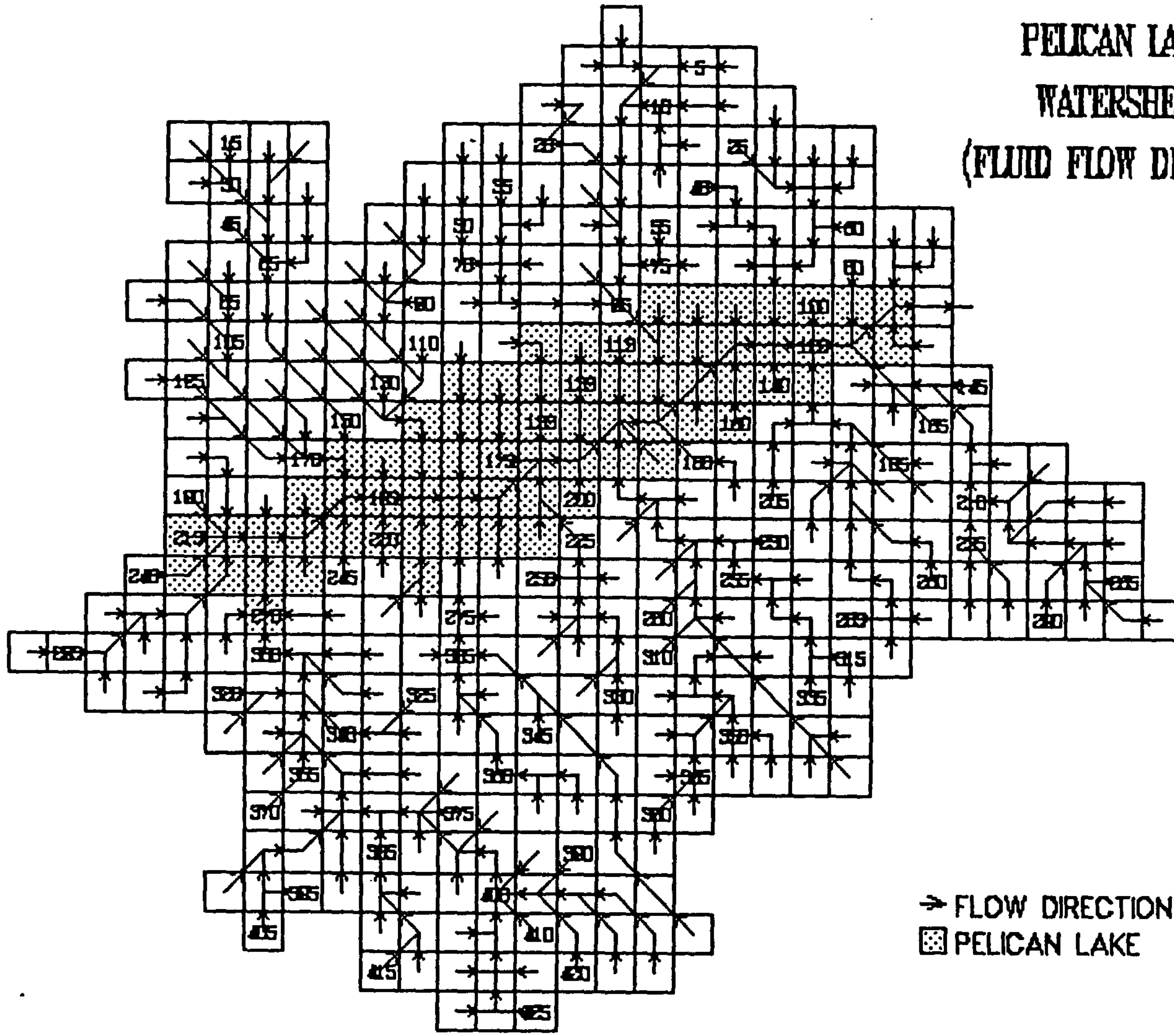
- PELICAN LAKE
- SUBWATERSHED 1, OUTLET CELL #170
- SUBWATERSHED 2, OUTLET CELL #150
- SUBWATERSHED 3, OUTLET CELL #151
- SUBWATERSHED 4, OUTLET CELL #95
- SUBWATERSHED 5, OUTLET CELL #78



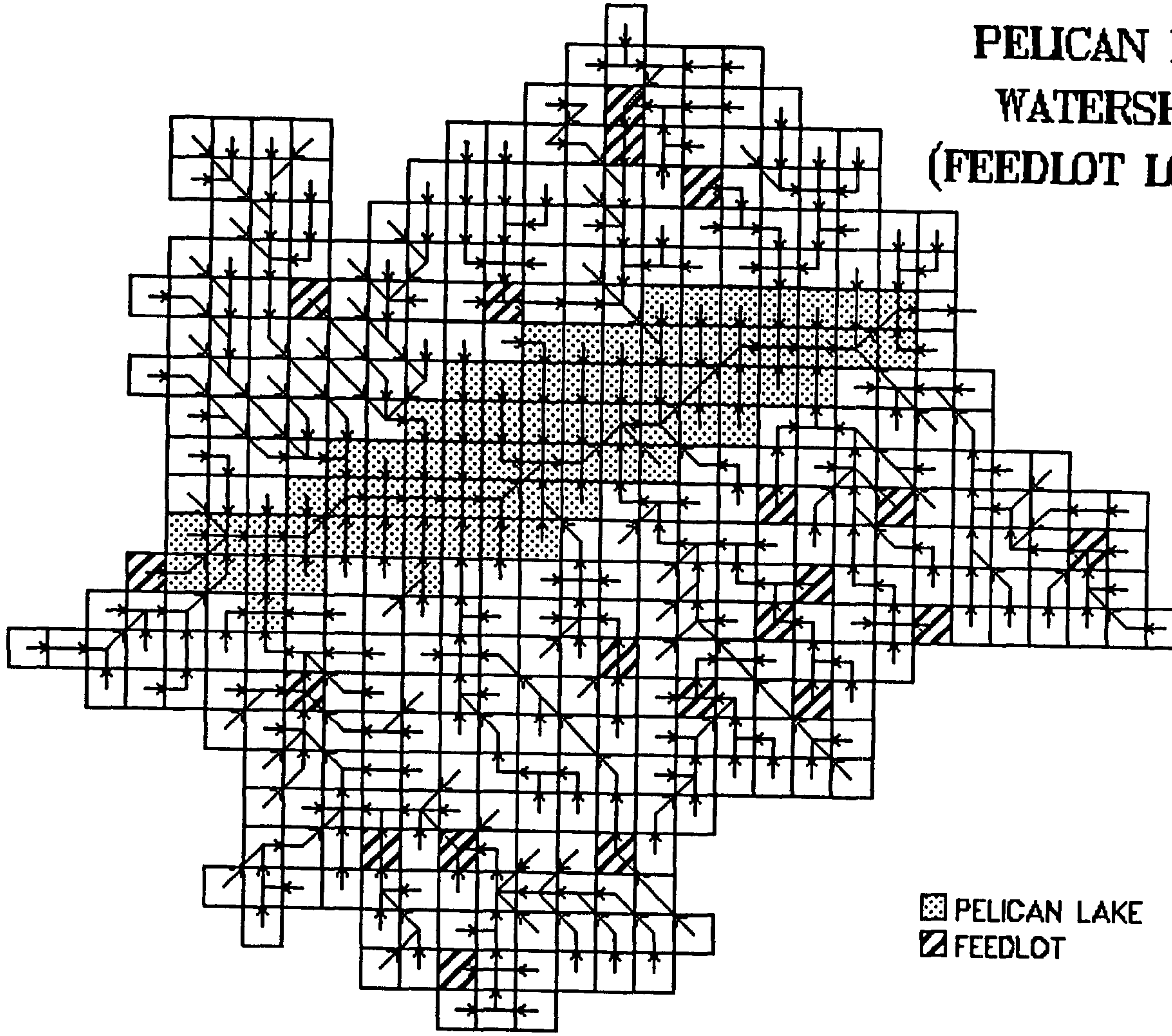


PELICAN LAKE
WATERSHED
(SOUTHERN SUBWATERSHEDS)

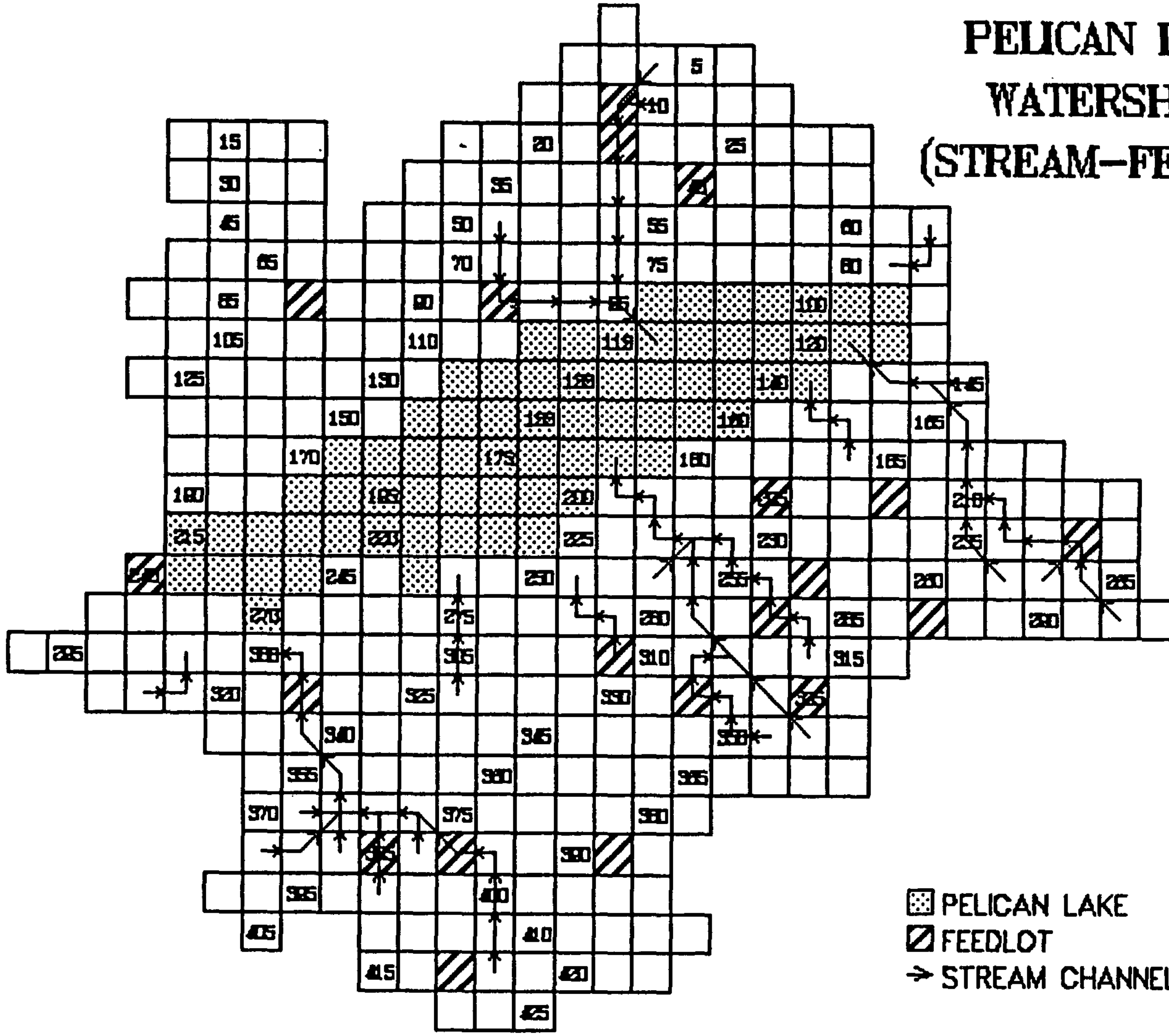
PELICAN LAKE
WATERSHED
(FLUID FLOW DIRECTION)



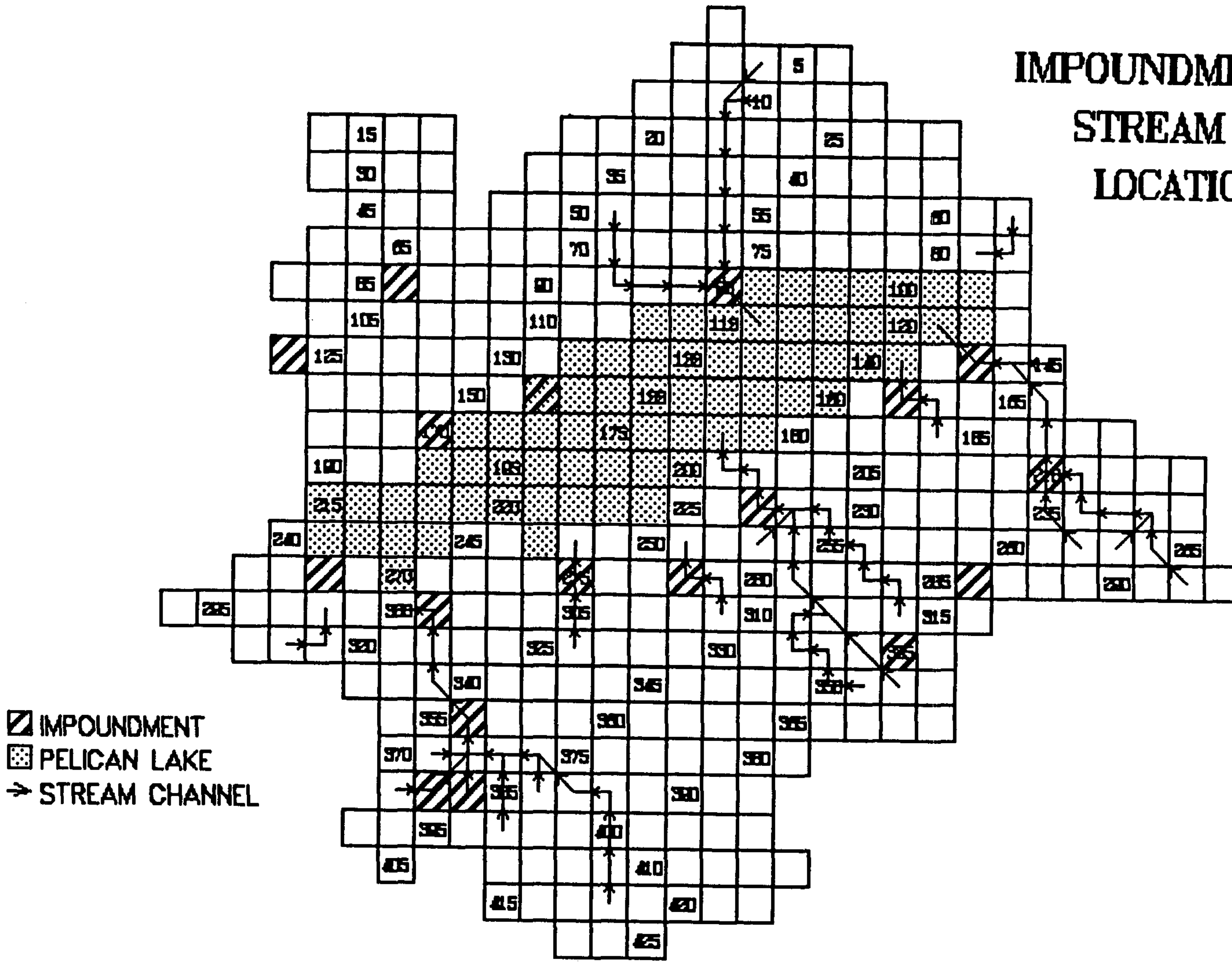
PELICAN LAKE WATERSHED (FEEDLOT LOCATION)



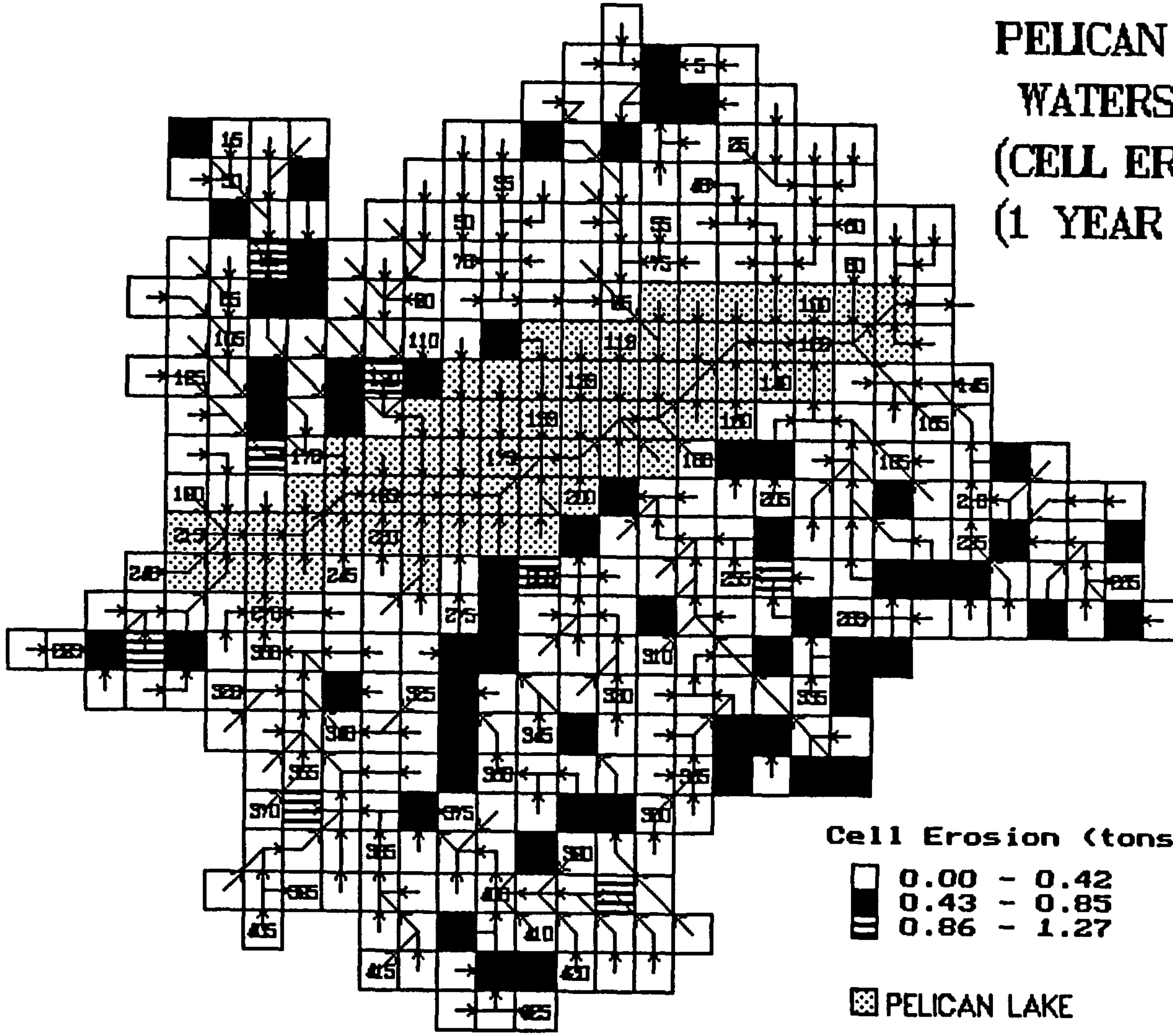
PELICAN LAKE WATERSHED (STREAM–FEEDLOTS)



IMPOUNDMENT AND STREAM FLOW LOCATIONS



PELICAN LAKE WATERSHED (CELL EROSION) (1 YEAR EVENT)

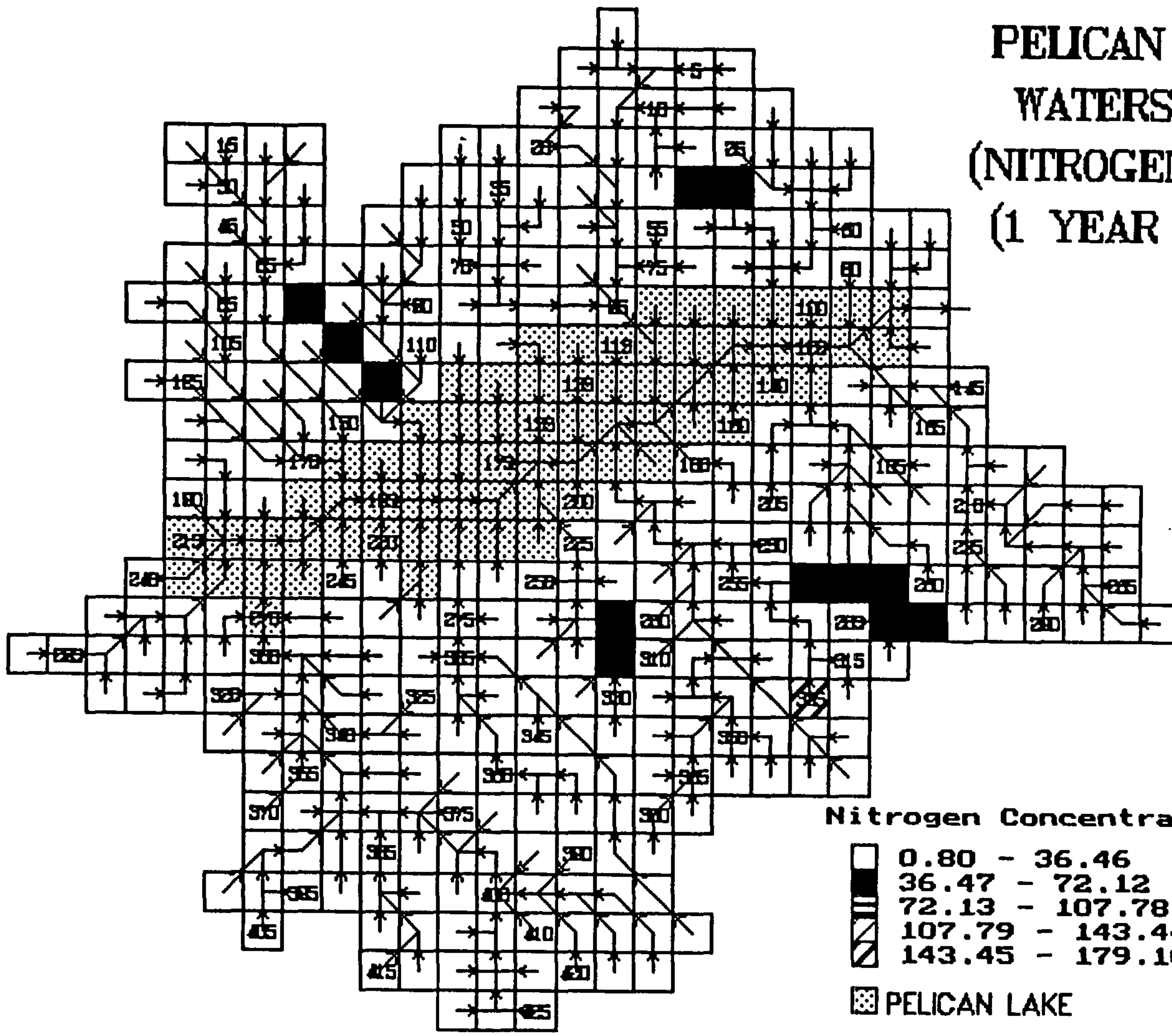


Cell Erosion (tons/acre)

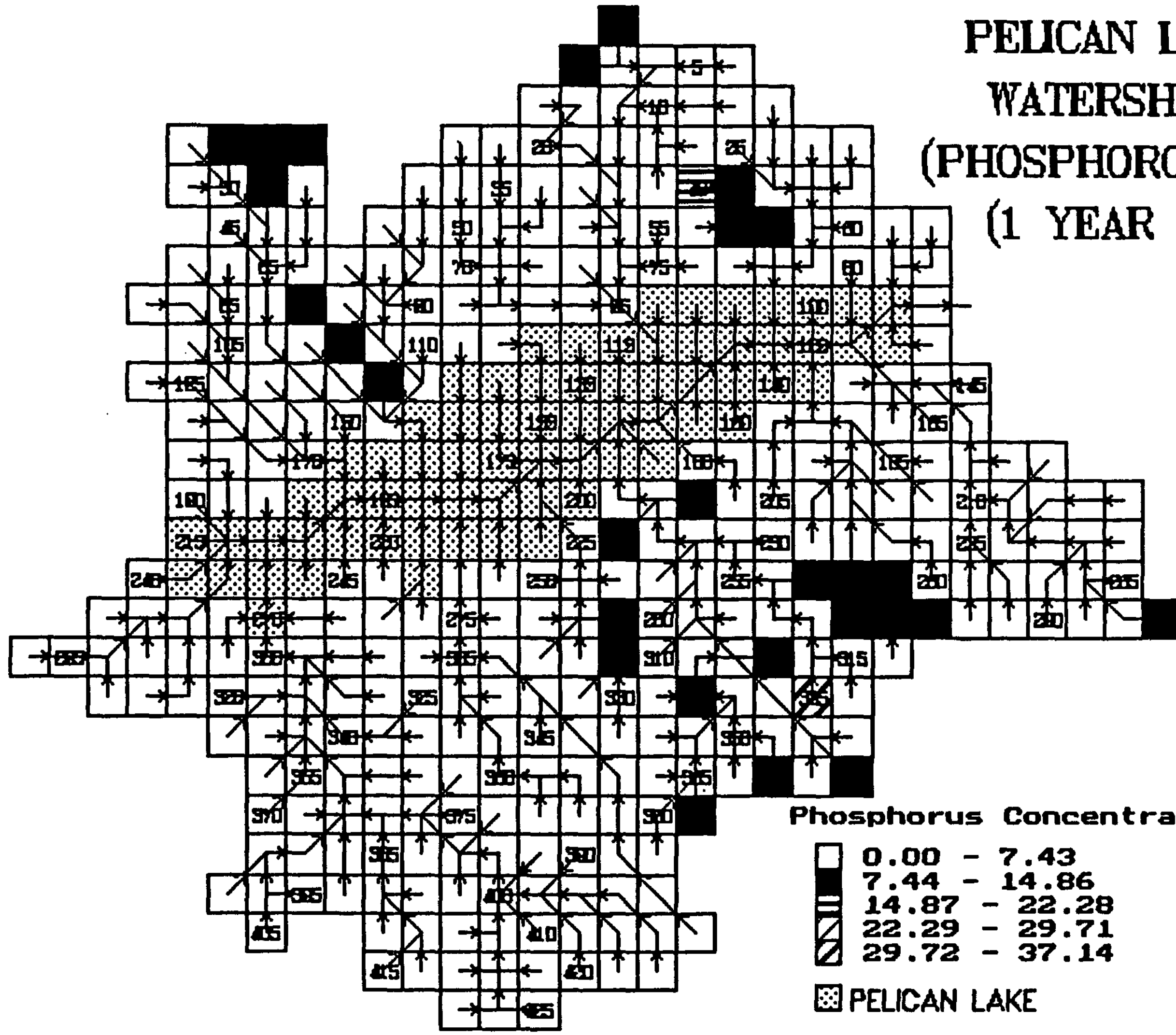
- 0.00 - 0.42
- 0.43 - 0.85
- 0.86 - 1.27

PELICAN LAKE

PELICAN LAKE WATERSHED (NITROGEN CON.) (1 YEAR EVENT)

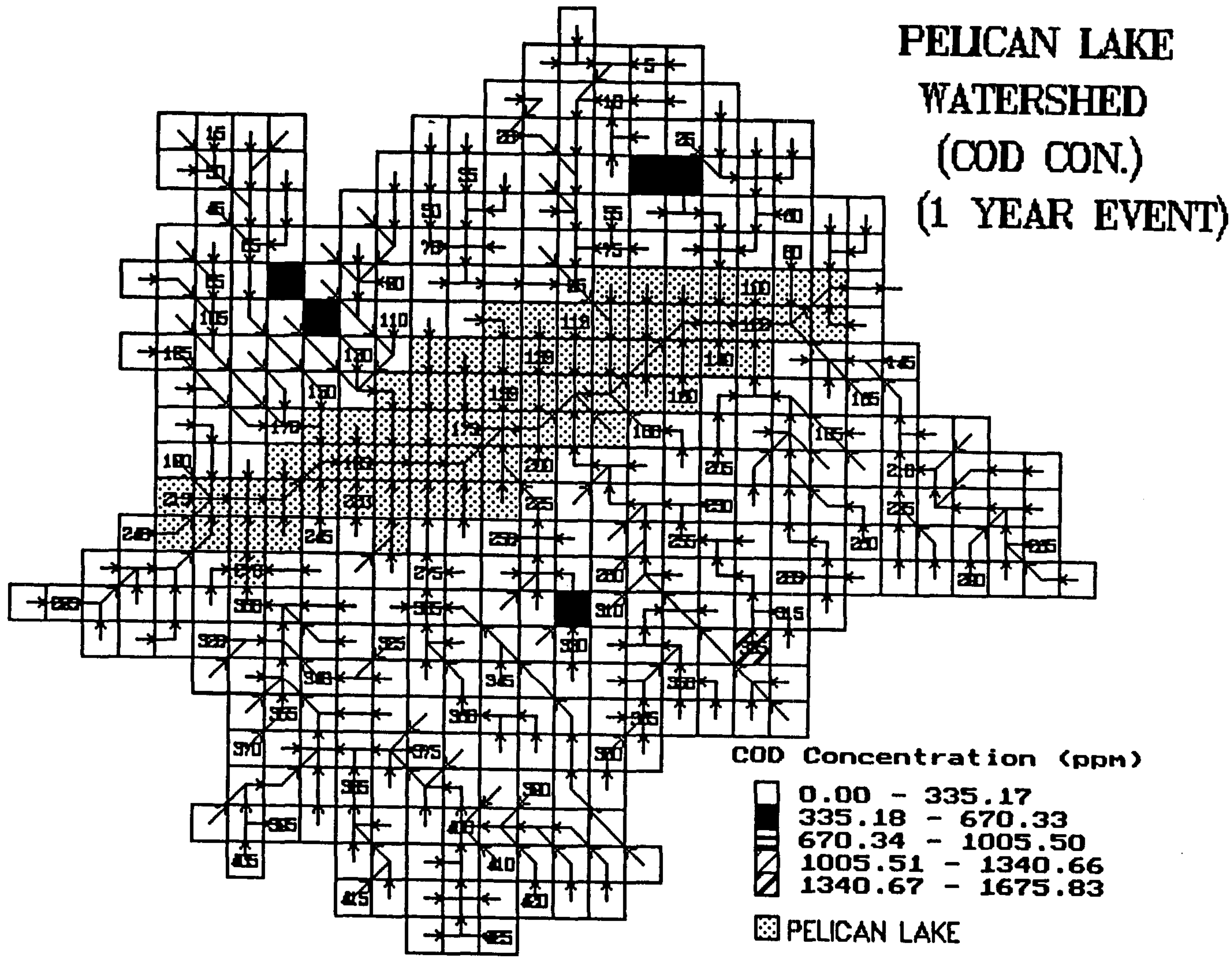


PELICAN LAKE WATERSHED (PHOSPHOROUS CON.) (1 YEAR EVENT)

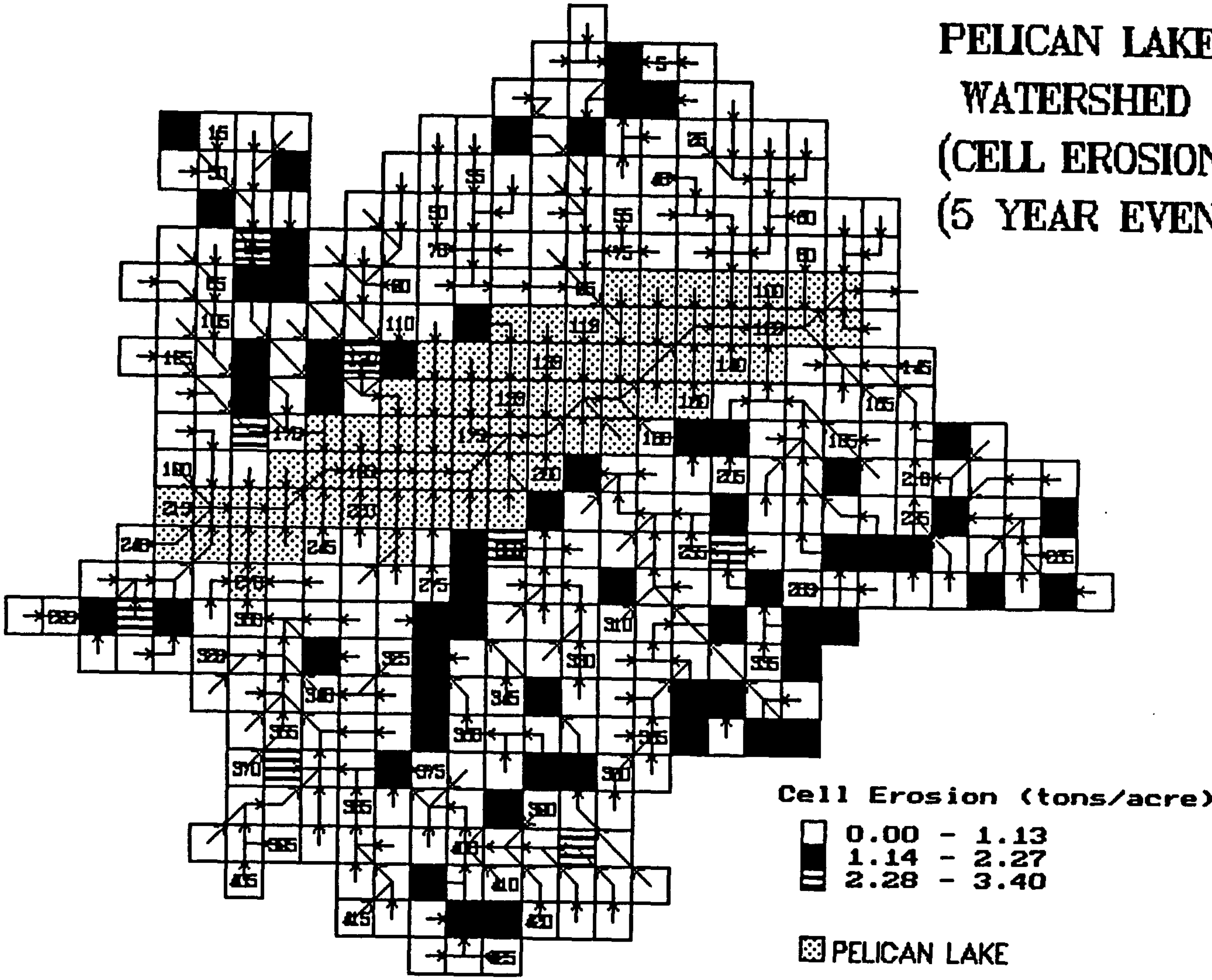


Phosphorus Concentration (ppm)

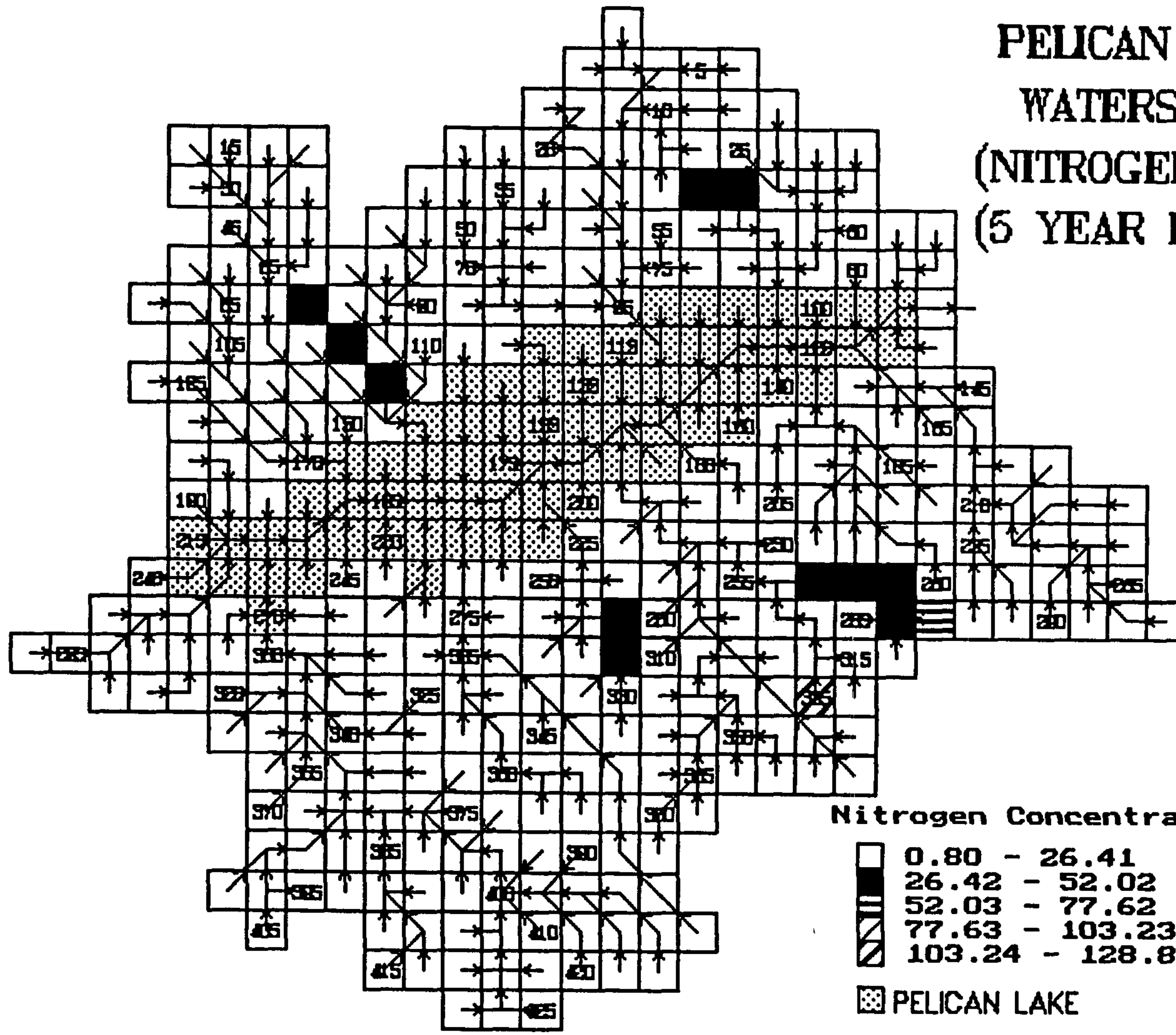
- 0.00 - 7.43
- 7.44 - 14.86
- 14.87 - 22.28
- 22.29 - 29.71
- 29.72 - 37.14
- PELICAN LAKE


PELICAN LAKE
WATERSHED
(COD CON.)
(1 YEAR EVENT)
COD Concentration (ppm)
0.00 - 335.17
335.18 - 670.33
670.34 - 1005.50
1005.51 - 1340.66
1340.67 - 1675.83
PELICAN LAKE

PELICAN LAKE WATERSHED (CELL EROSION) (5 YEAR EVENT)



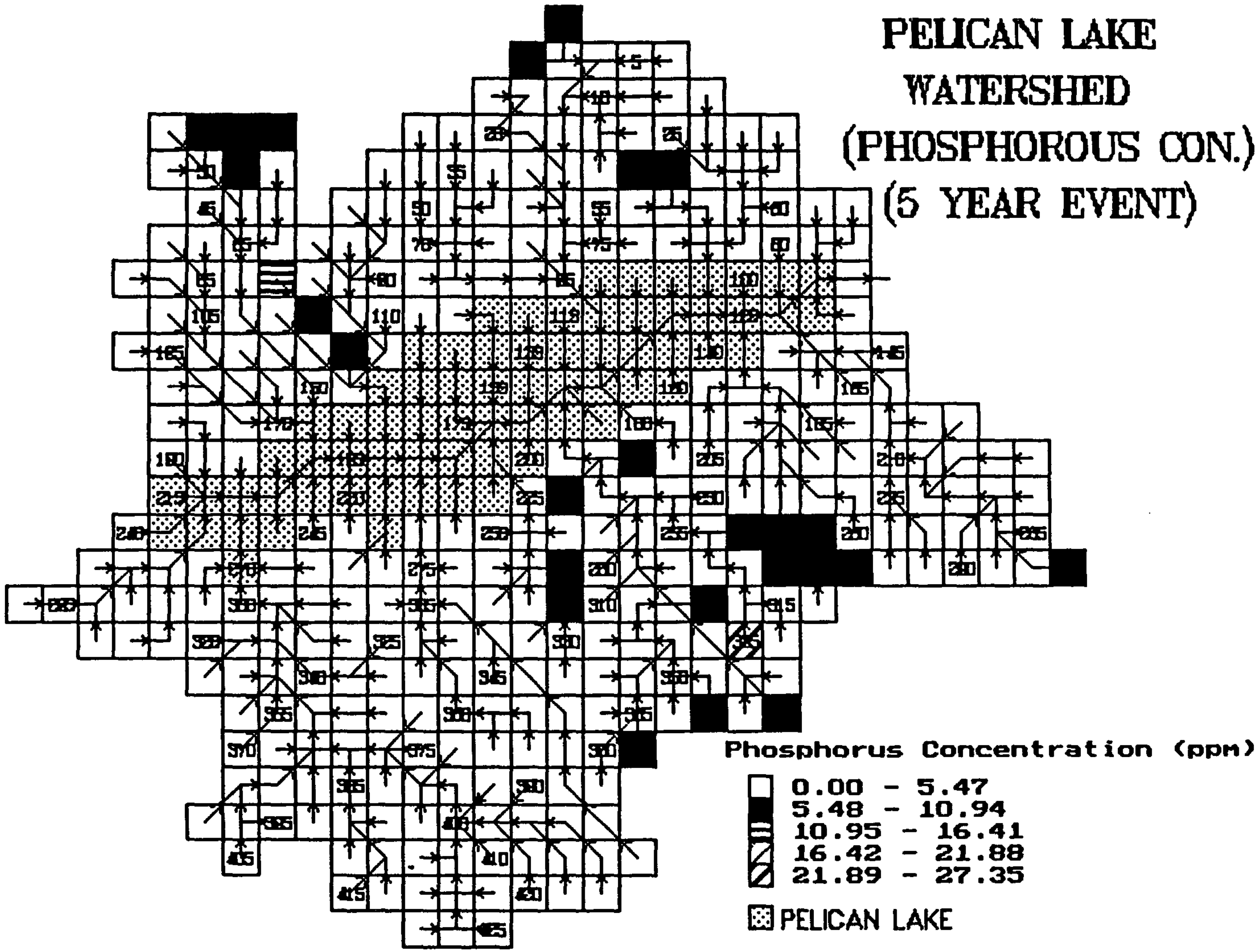
PELICAN LAKE WATERSHED (NITROGEN CON.) (5 YEAR EVENT)



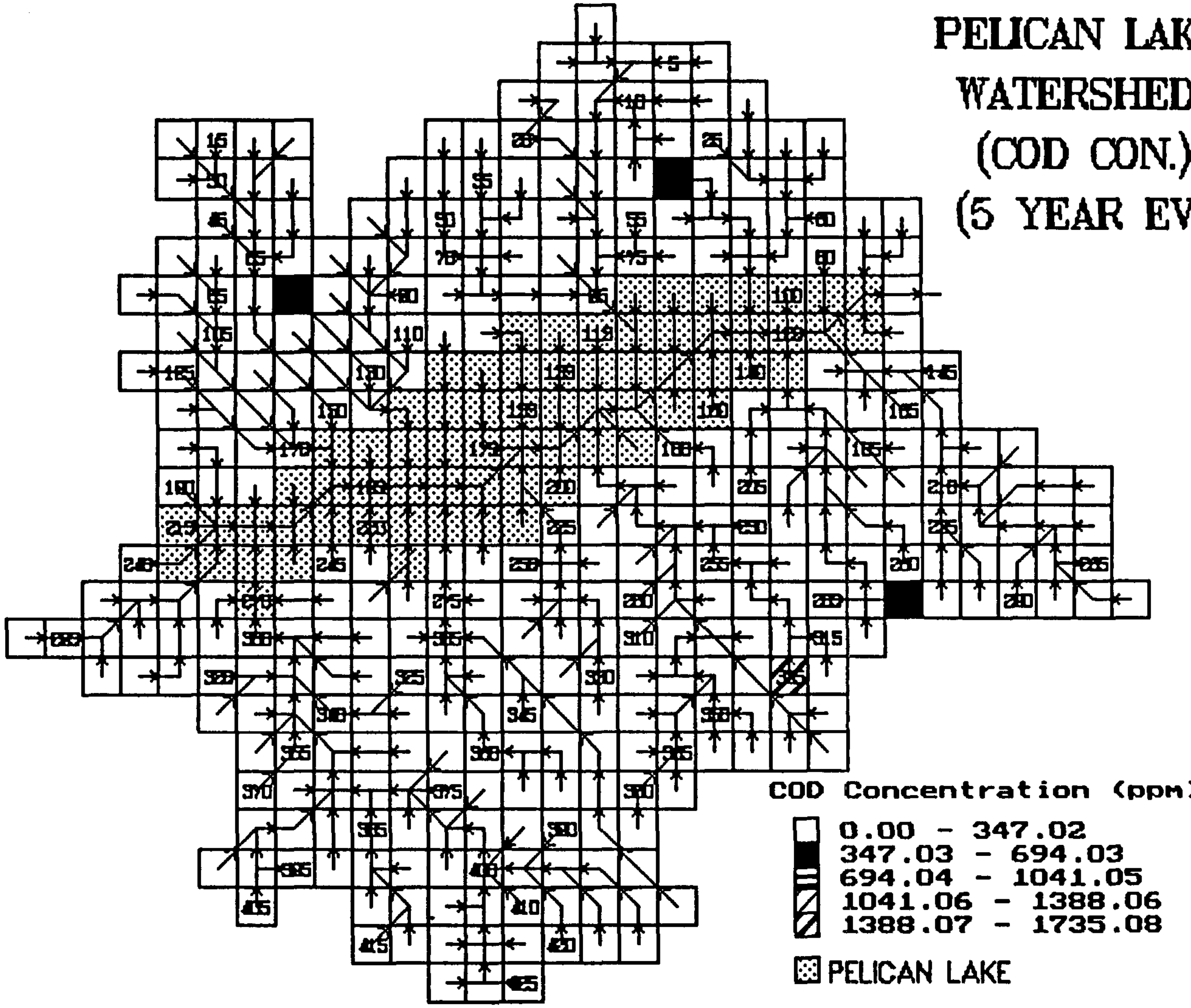
Nitrogen Concentration (ppm)

- 0.80 - 26.41
- 26.42 - 52.02
- 52.03 - 77.62
- 77.63 - 103.23
- 103.24 - 128.84
- PELICAN LAKE

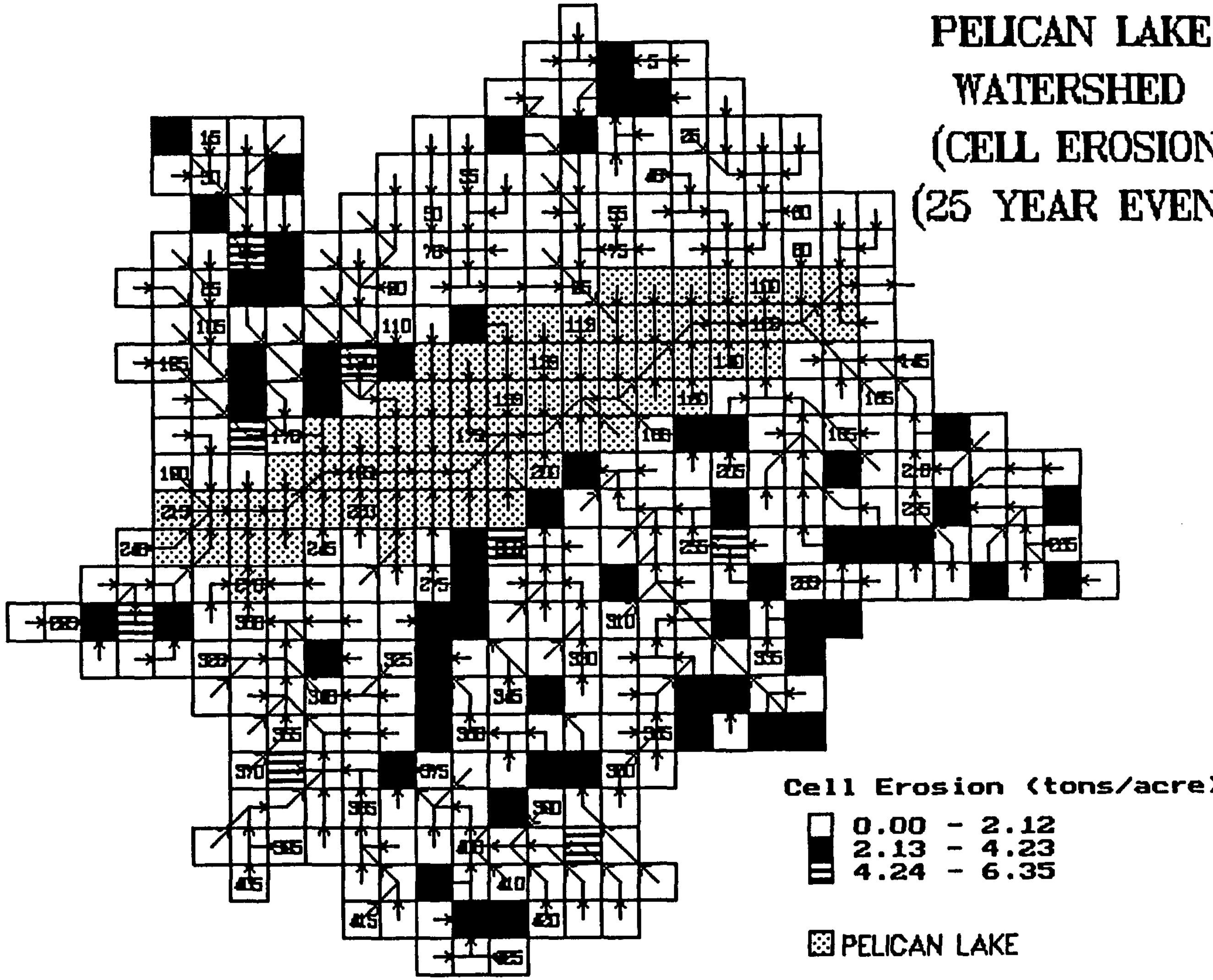
PELICAN LAKE WATERSHED (PHOSPHOROUS CON.) (5 YEAR EVENT)



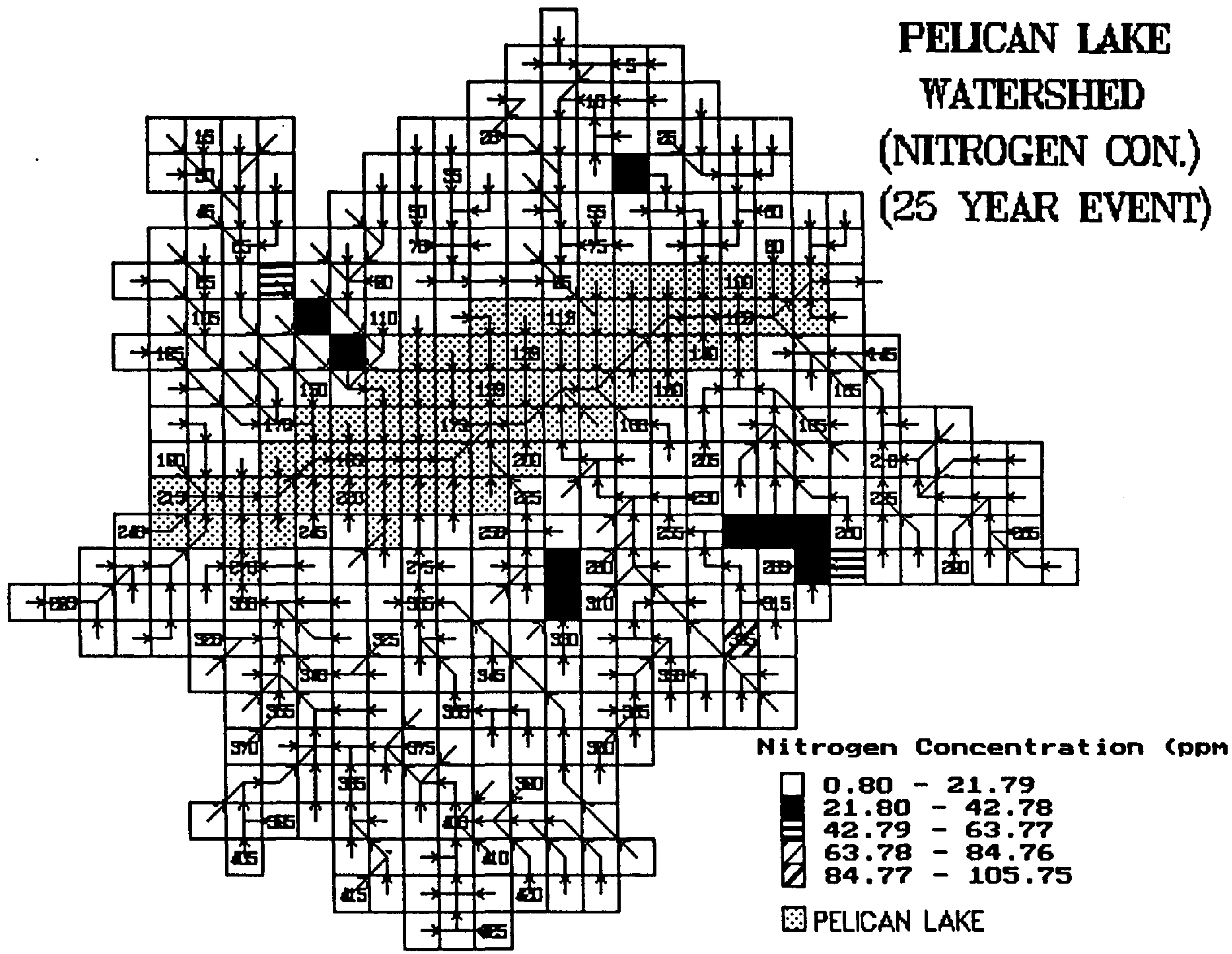
PELICAN LAKE WATERSHED (COD CON.) (5 YEAR EVENT)

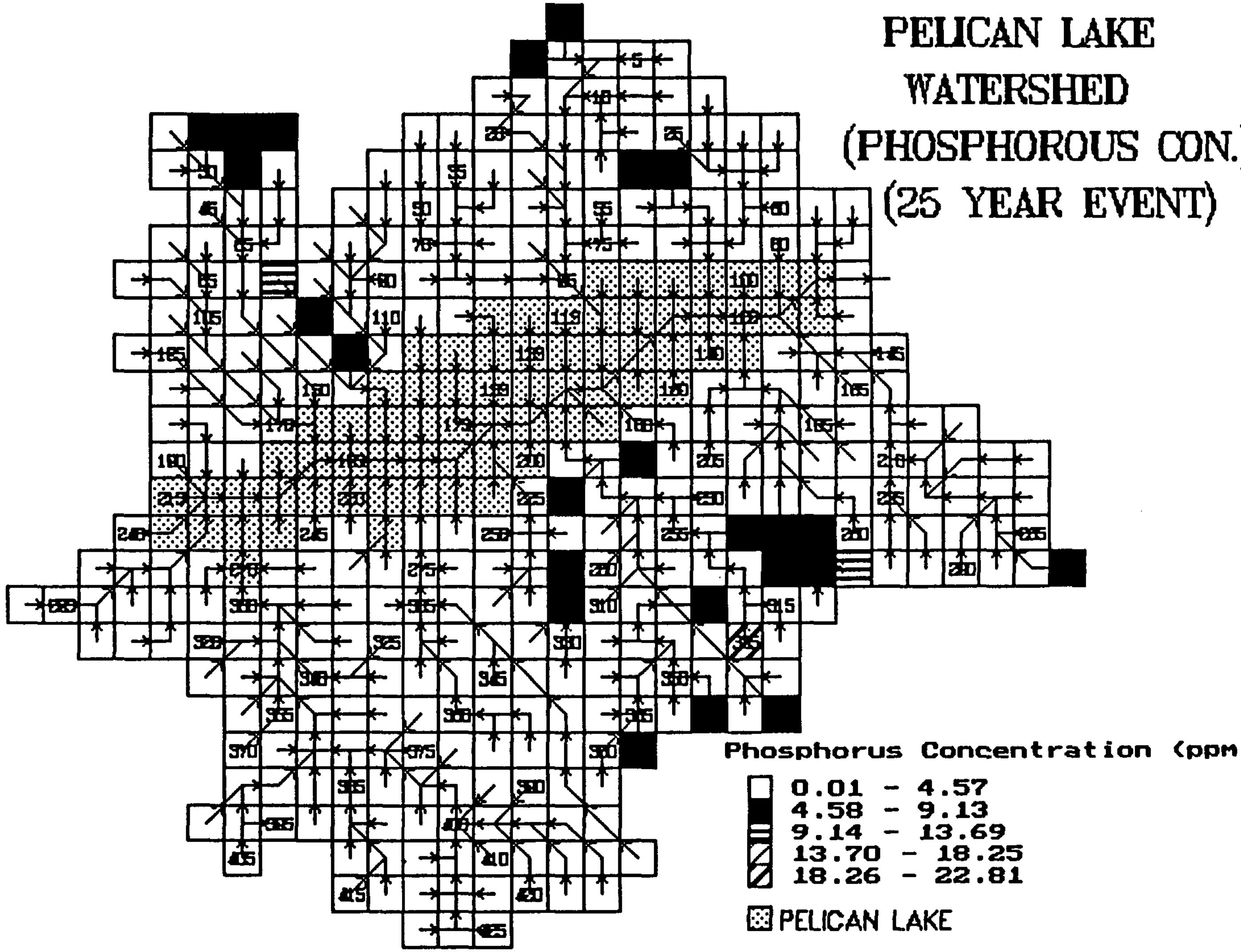


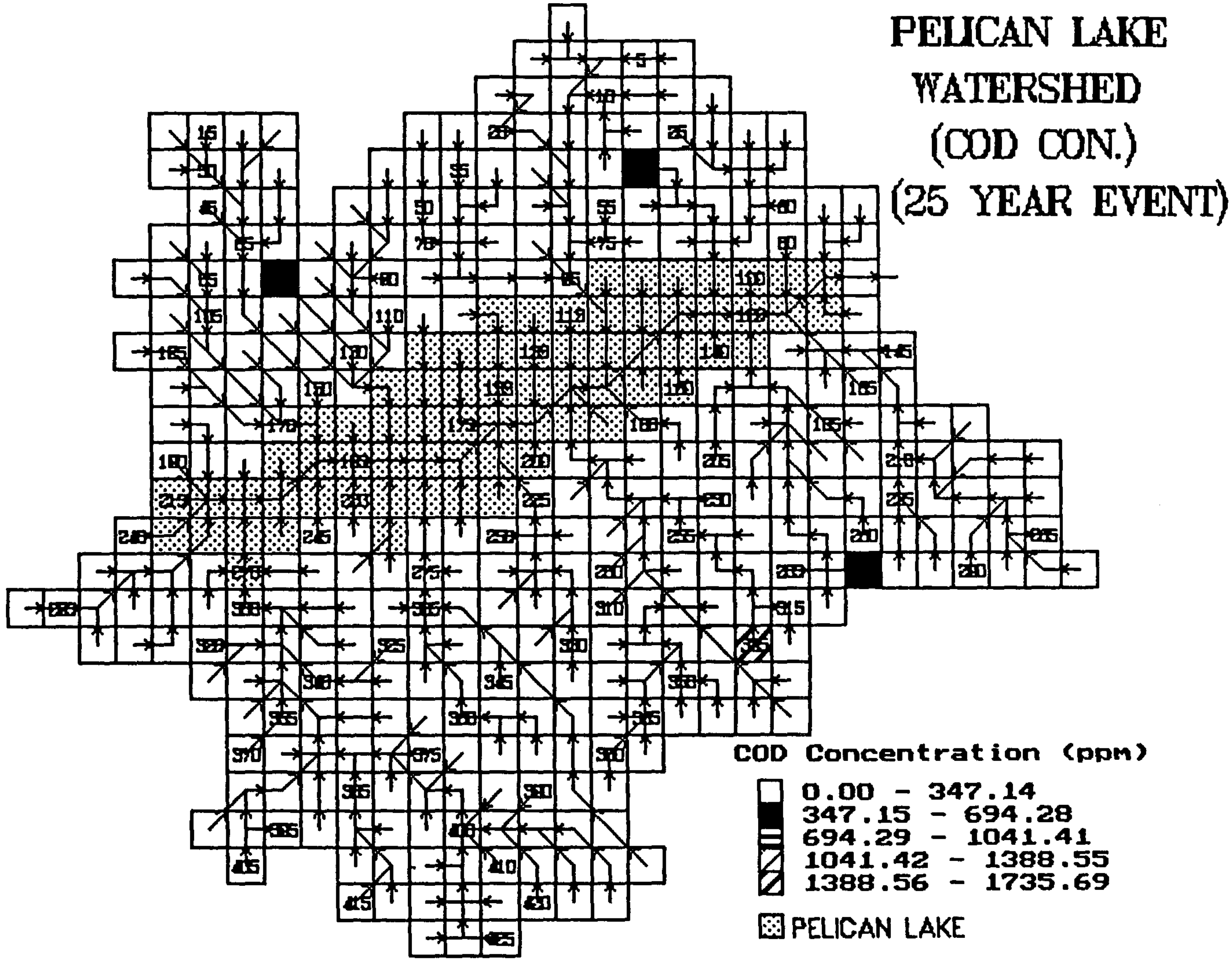
PELICAN LAKE WATERSHED (CELL EROSION) (25 YEAR EVENT)



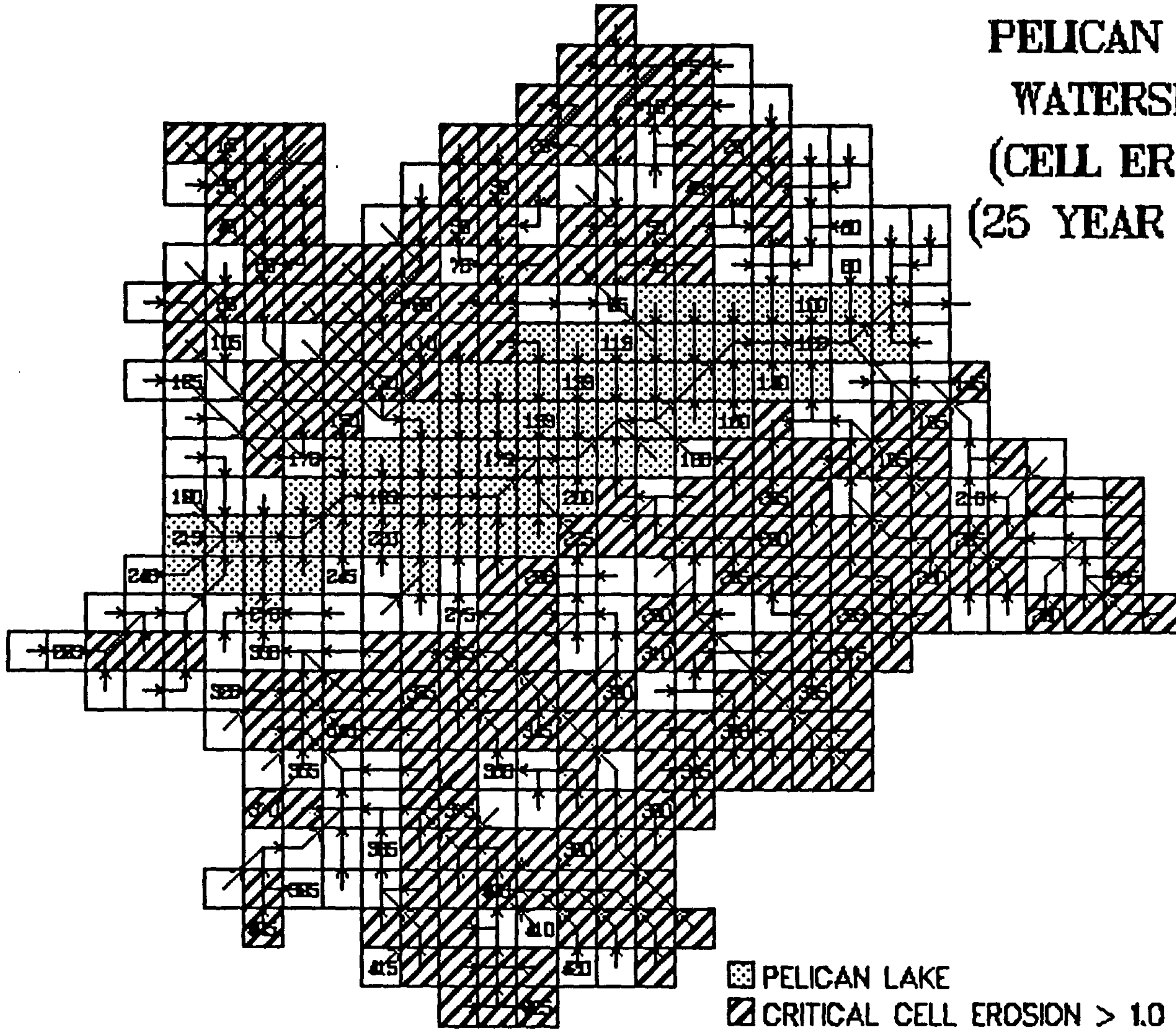
PELICAN LAKE WATERSHED (NITROGEN CON.) (25 YEAR EVENT)




PELICAN LAKE
WATERSHED
(PHOSPHOROUS CON.)
(25 YEAR EVENT)
Phosphorus Concentration (ppm)
0.01 - 4.57
4.58 - 9.13
9.14 - 13.69
13.70 - 18.25
18.26 - 22.81
PELICAN LAKE

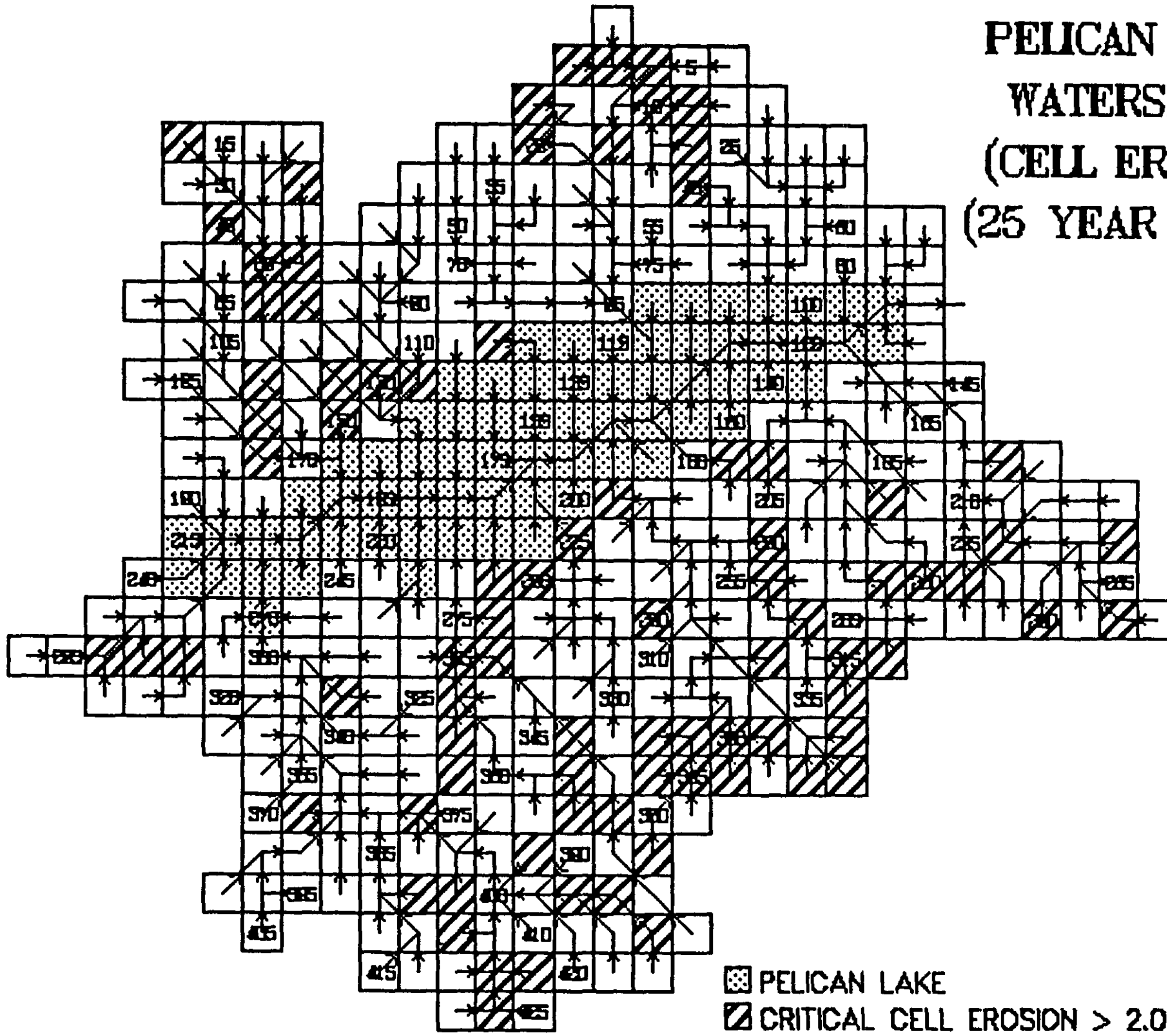

PELICAN LAKE
WATERSHED
(COD CON.)
(25 YEAR EVENT)
COD Concentration (ppm)
0.00 - 347.14
347.15 - 694.28
694.29 - 1041.41
1041.42 - 1388.55
1388.56 - 1735.69
PELICAN LAKE

PELICAN LAKE WATERSHED (CELL EROSION) (25 YEAR EVENT)



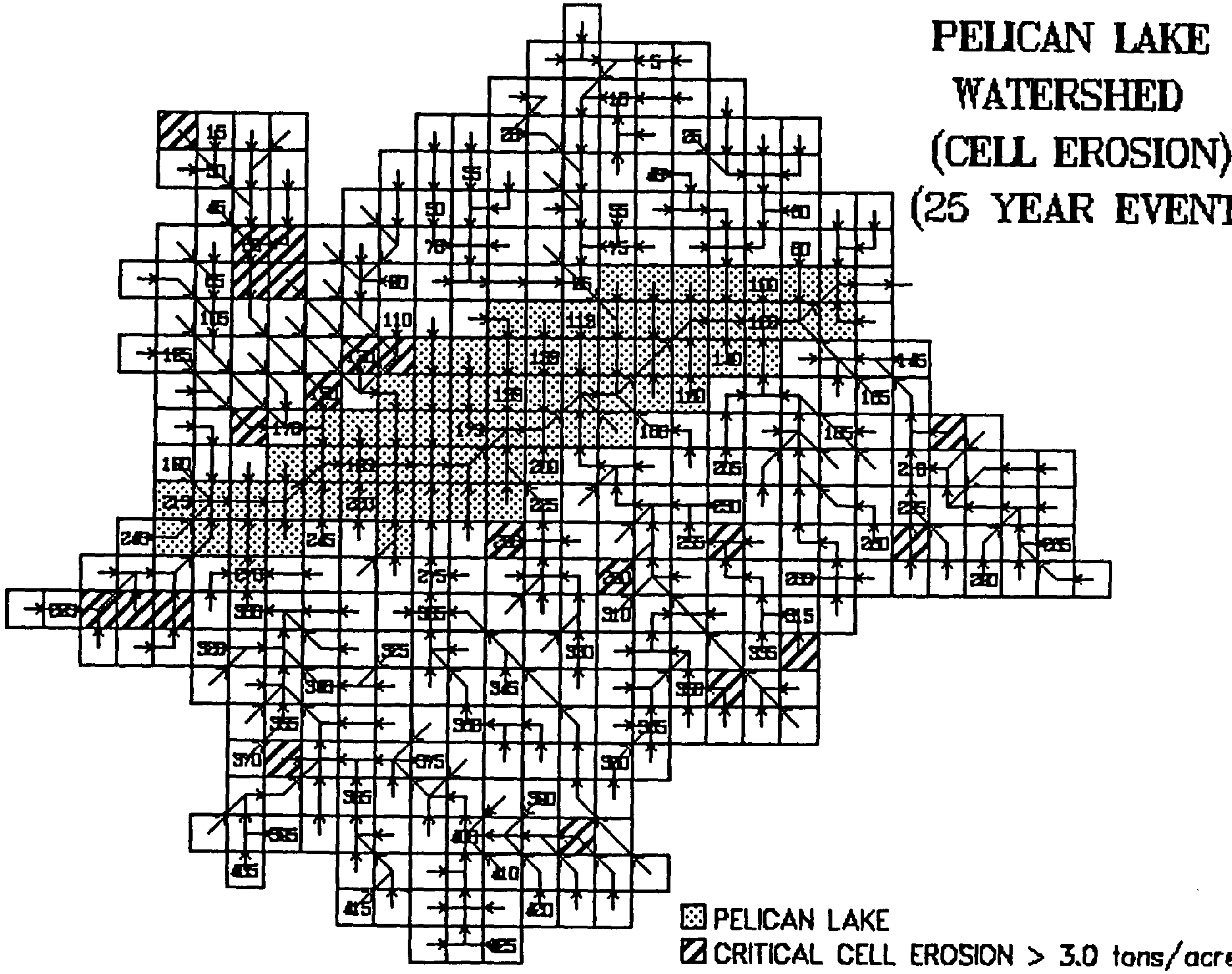
PELICAN LAKE
CRITICAL CELL EROSION > 1.0 tons/acre

PELICAN LAKE WATERSHED (CELL EROSION) (25 YEAR EVENT)

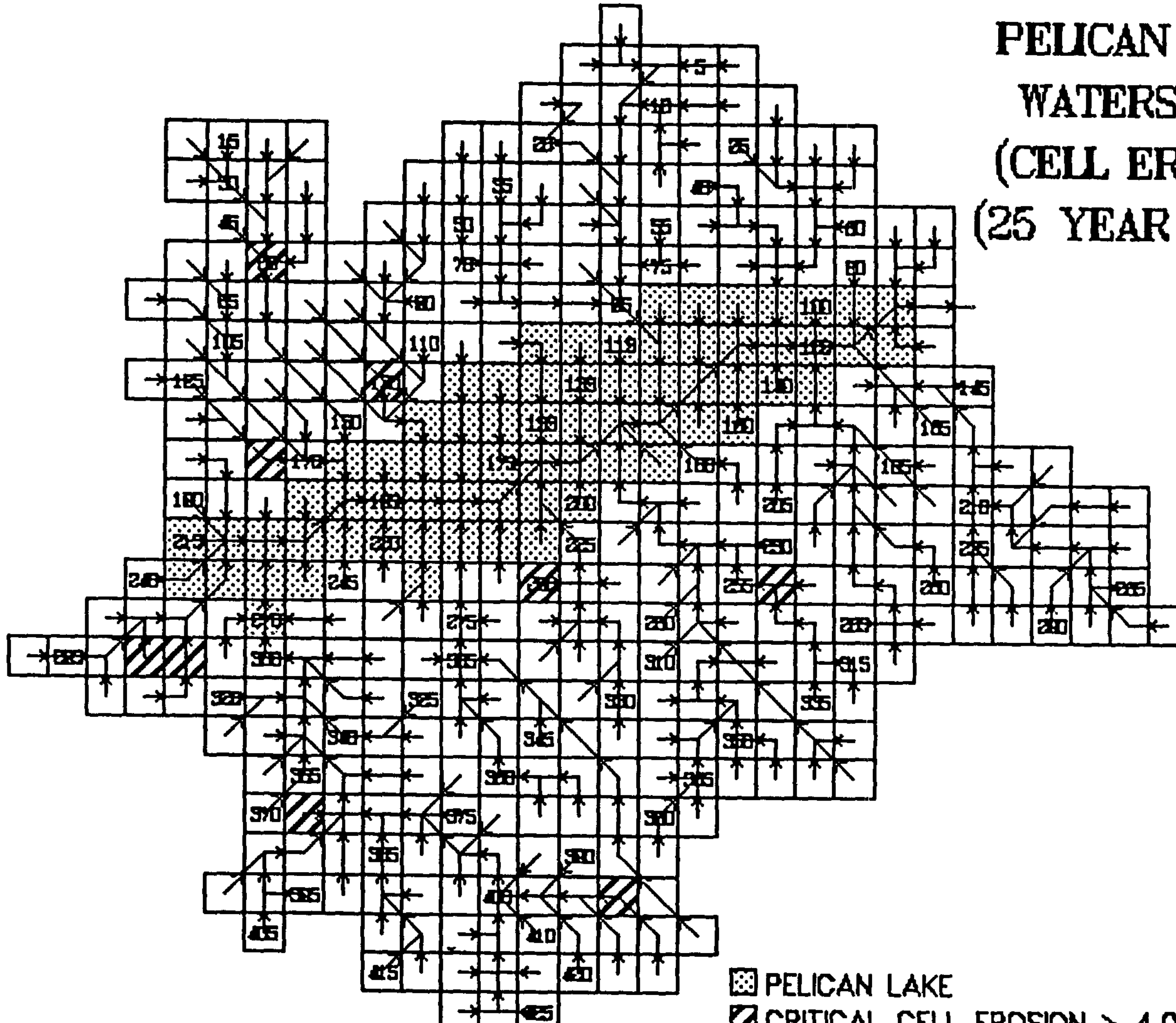


PELICAN LAKE
CRITICAL CELL EROSION > 2.0 tons/acre

PELICAN LAKE WATERSHED (CELL EROSION) (25 YEAR EVENT)

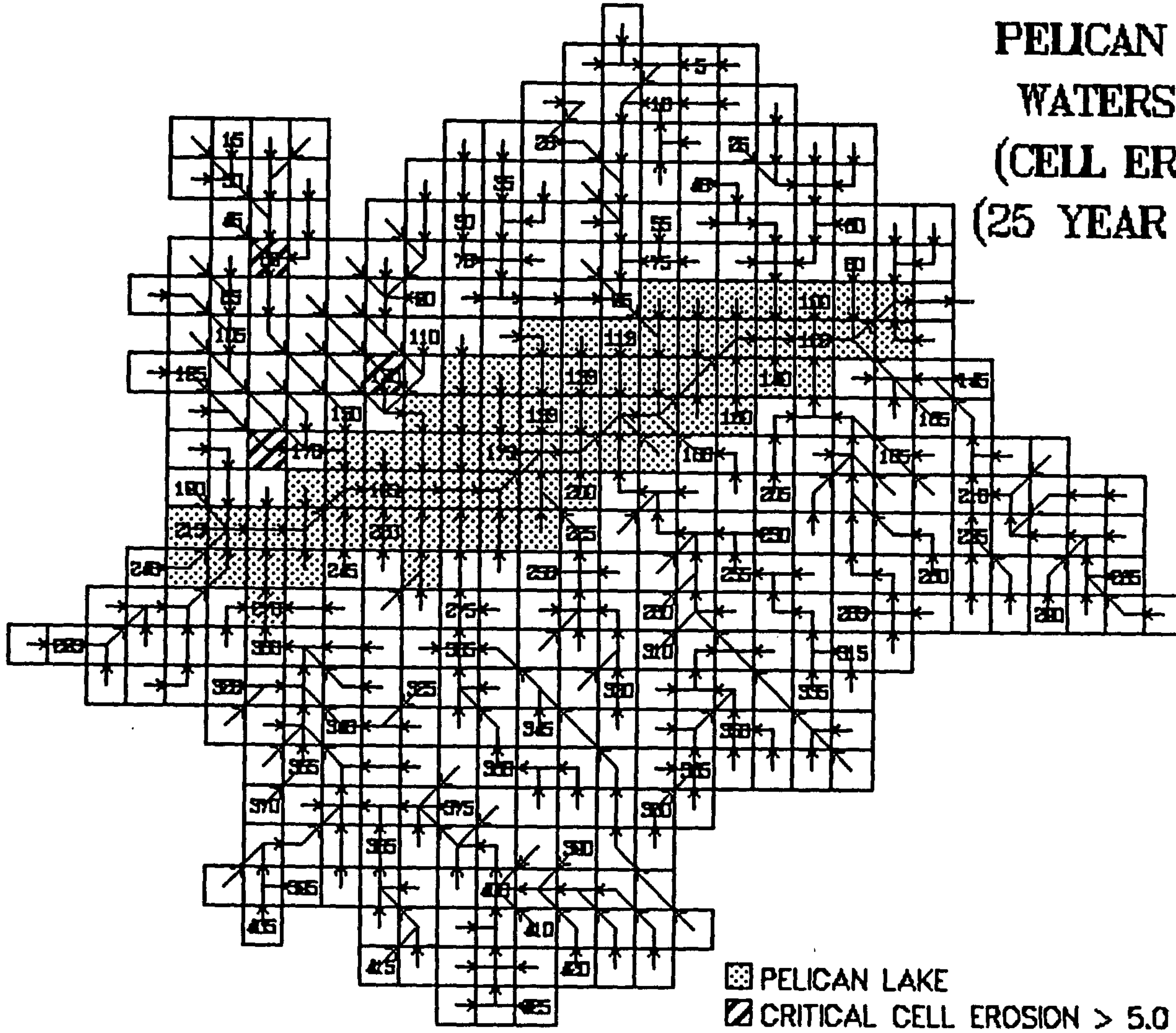


PELICAN LAKE WATERSHED (CELL EROSION) (25 YEAR EVENT)



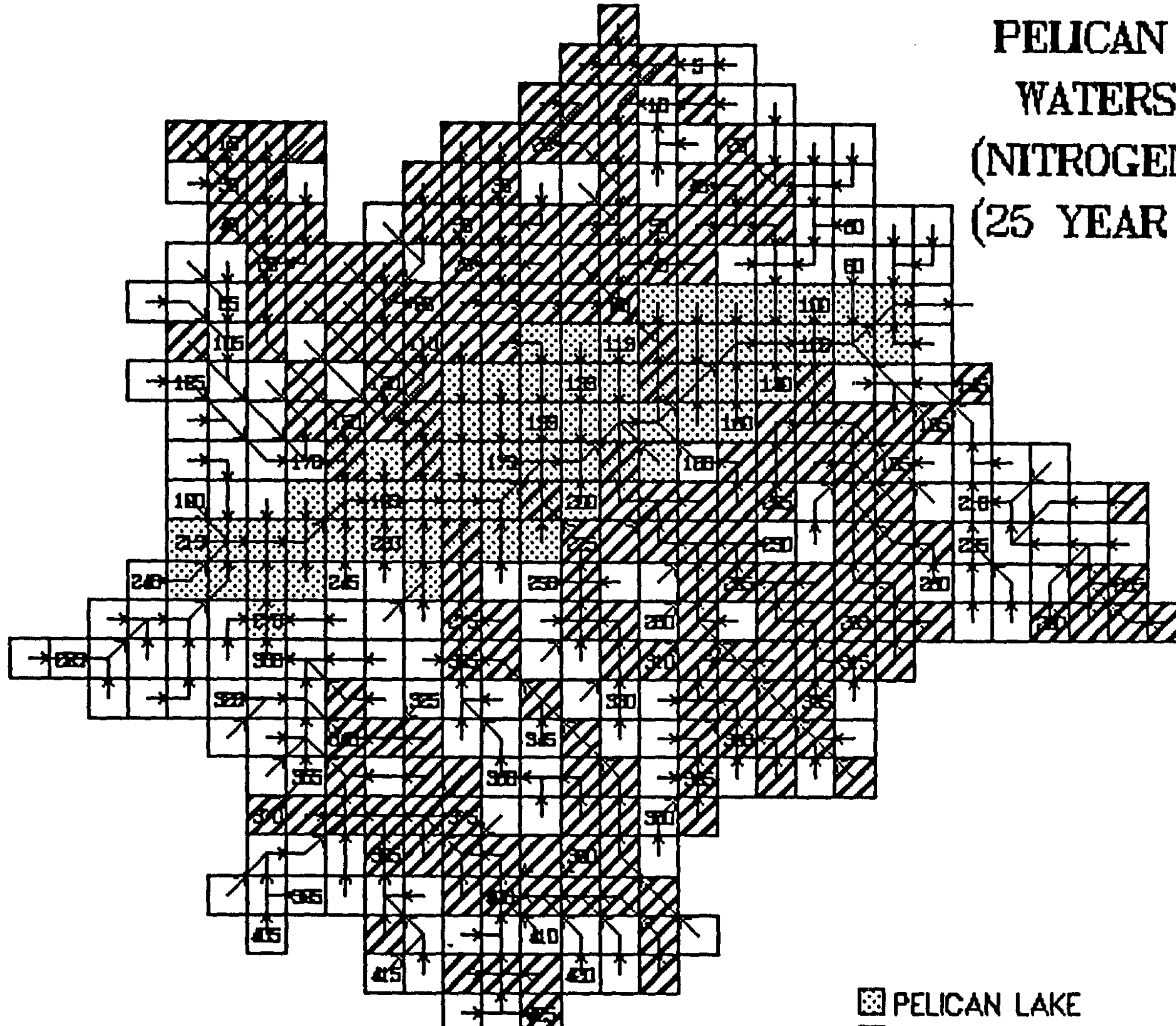
PELICAN LAKE
CRITICAL CELL EROSION > 4.0 tons/acre

PELICAN LAKE WATERSHED (CELL EROSION) (25 YEAR EVENT)



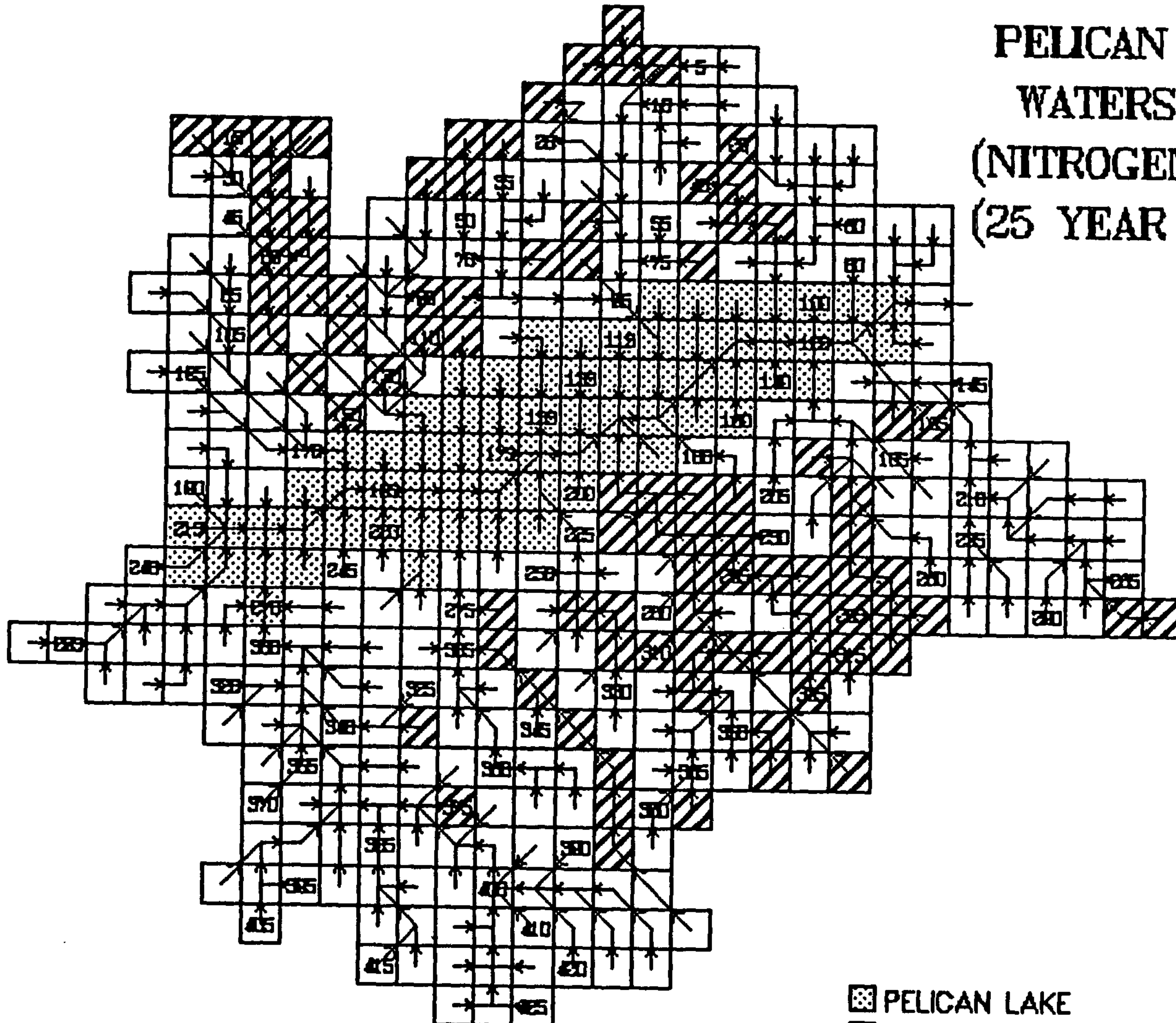
PELICAN LAKE
CRITICAL CELL EROSION > 5.0 tons/acre

PELICAN LAKE WATERSHED
(NITROGEN CON.)
(25 YEAR EVENT)



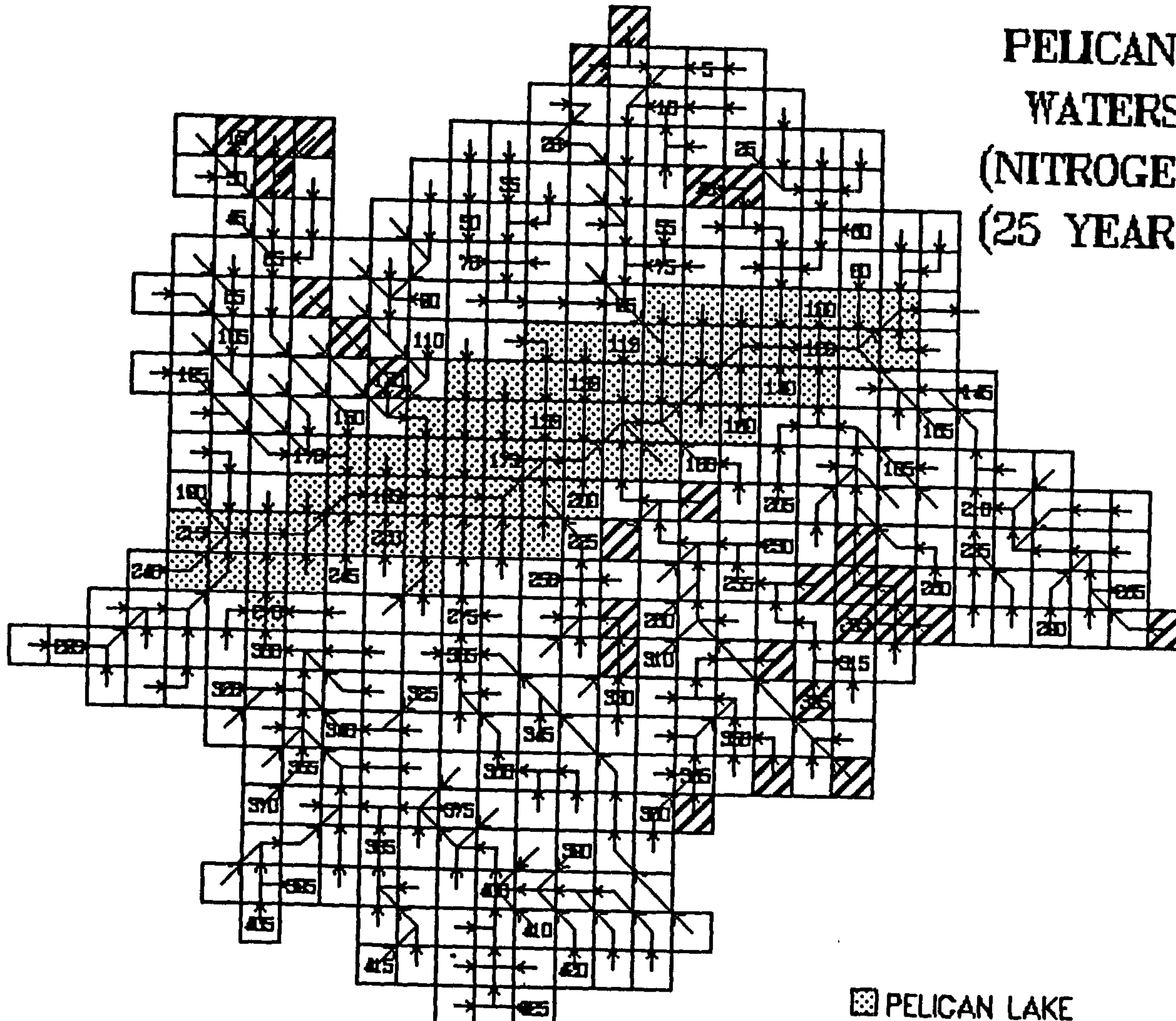
PELICAN LAKE
NITROGEN CON. > 10 ppm

PELICAN LAKE
WATERSHED
(NITROGEN CON.)
(25 YEAR EVENT)

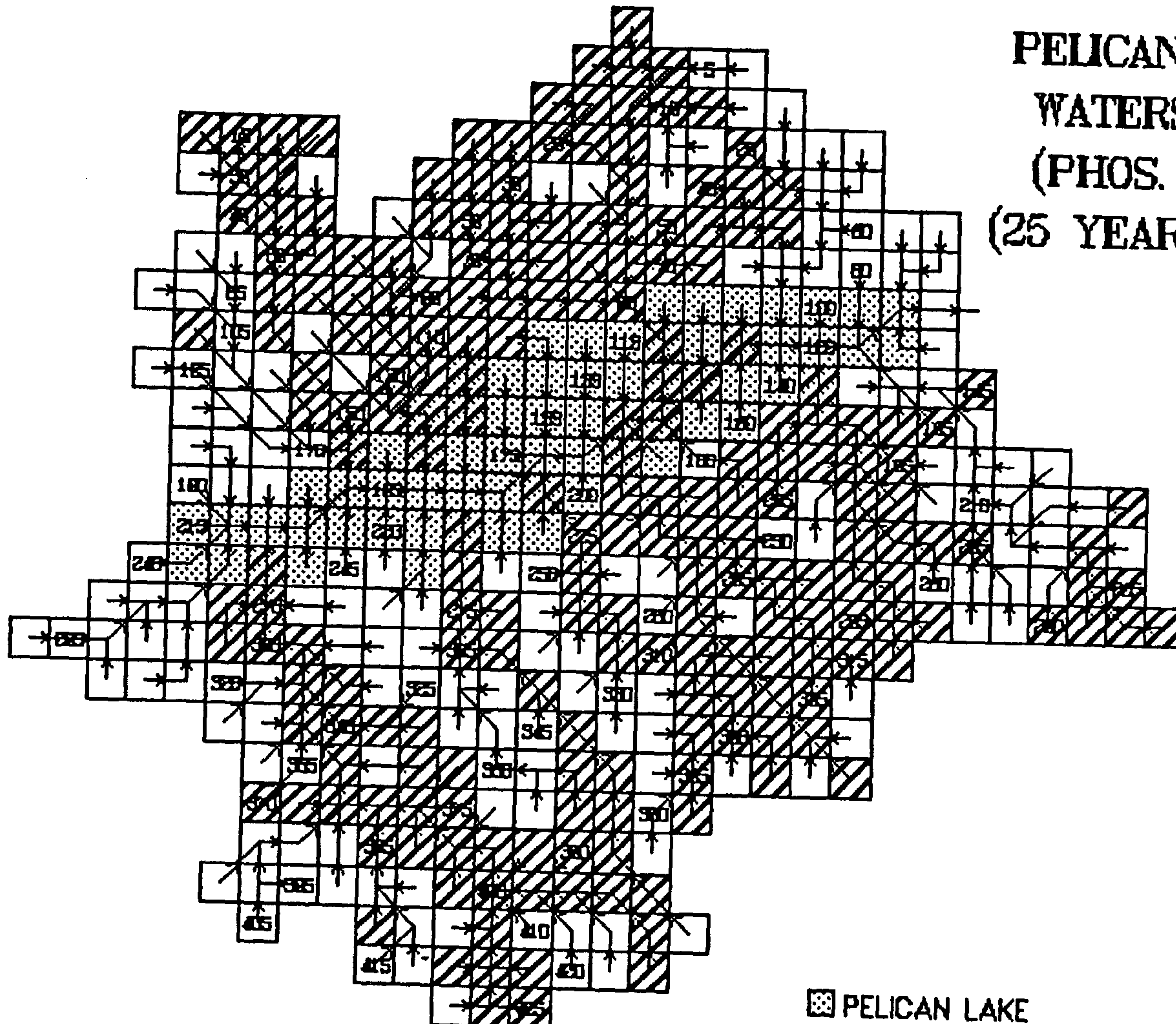


PELICAN LAKE
NITROGEN CON. > 15 ppm

PELICAN LAKE WATERSHED (NITROGEN CON.) (25 YEAR EVENT)

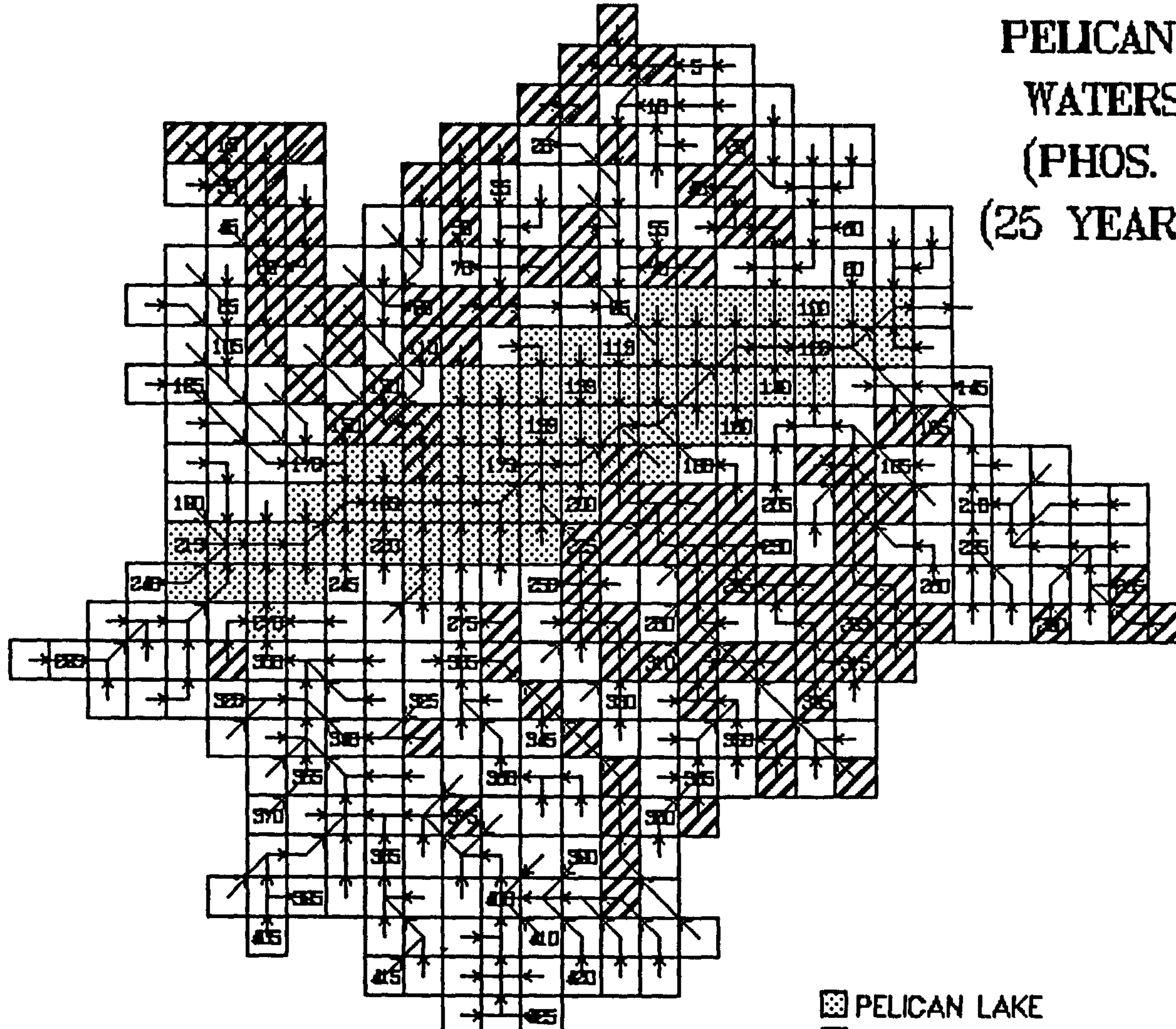


PELICAN LAKE WATERSHED (PHOS. CON.) (25 YEAR EVENT)



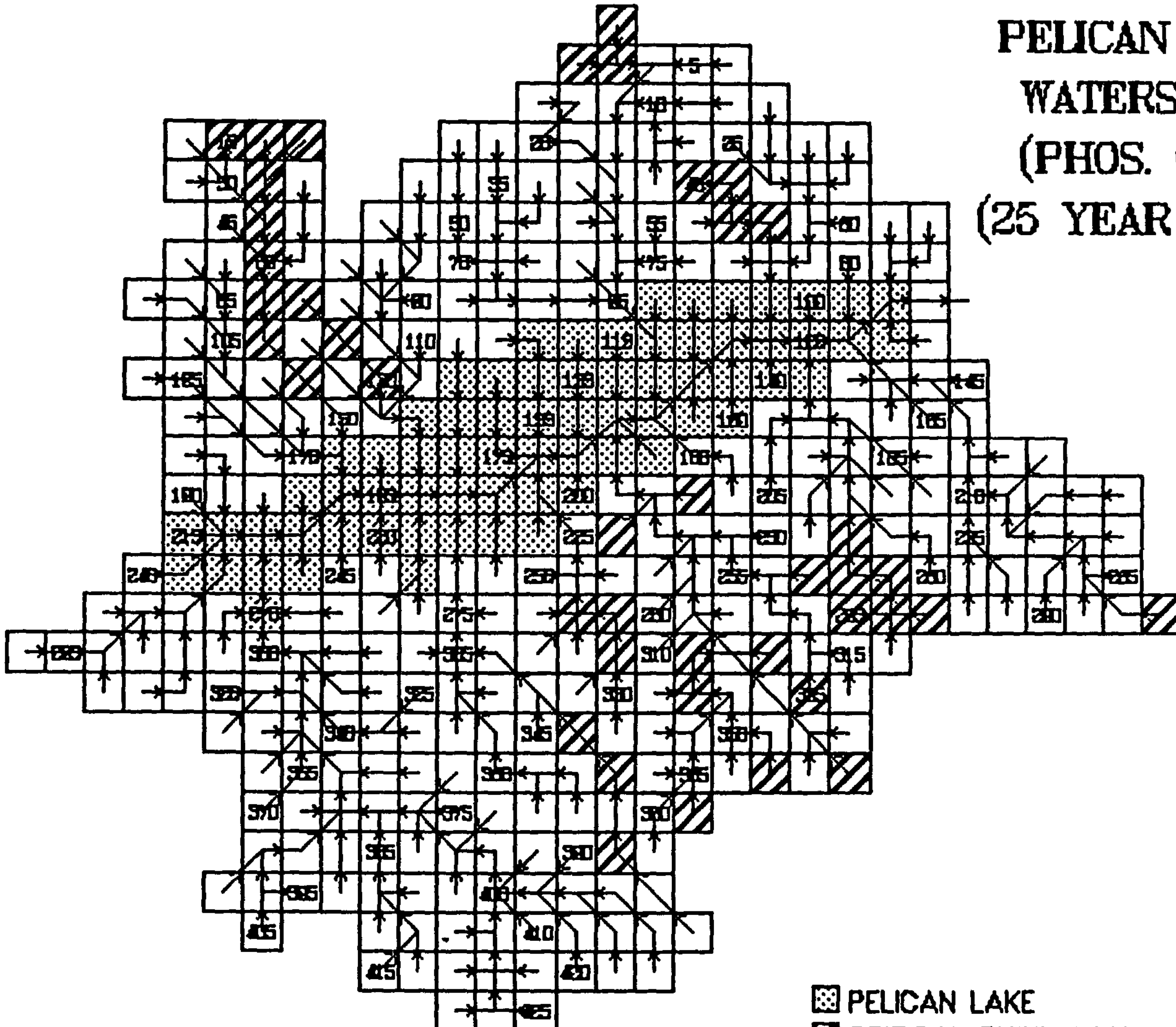
PELICAN LAKE
CRITICAL PHOS. CON. > 2.0 ppm

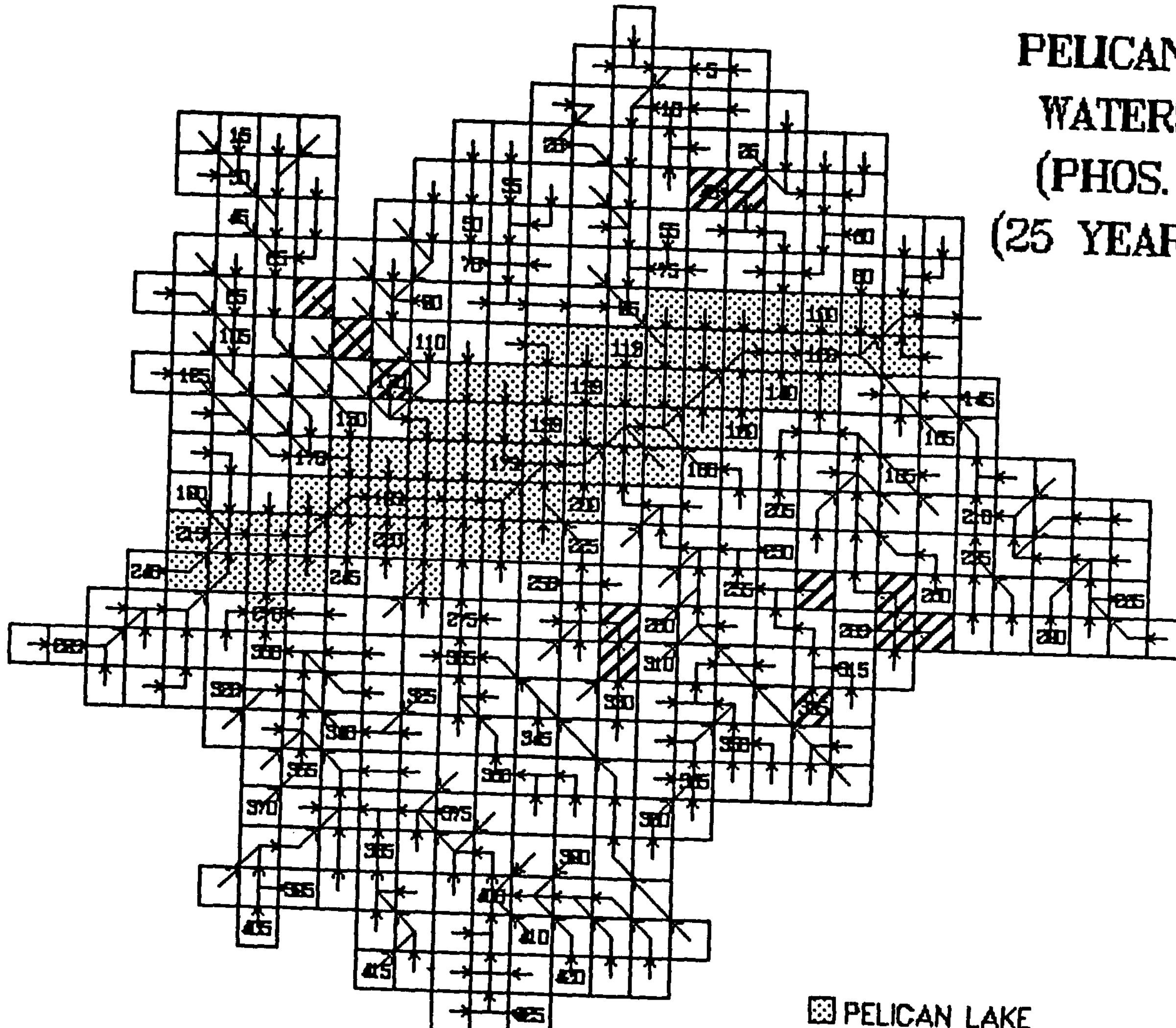
PELICAN LAKE WATERSHED (PHOS. CON.) (25 YEAR EVENT)



PELICAN LAKE
CRITICAL PHOS. CON. > 3.0 ppm

PELICAN LAKE WATERSHED (PHOS. CON.) (25 YEAR EVENT)

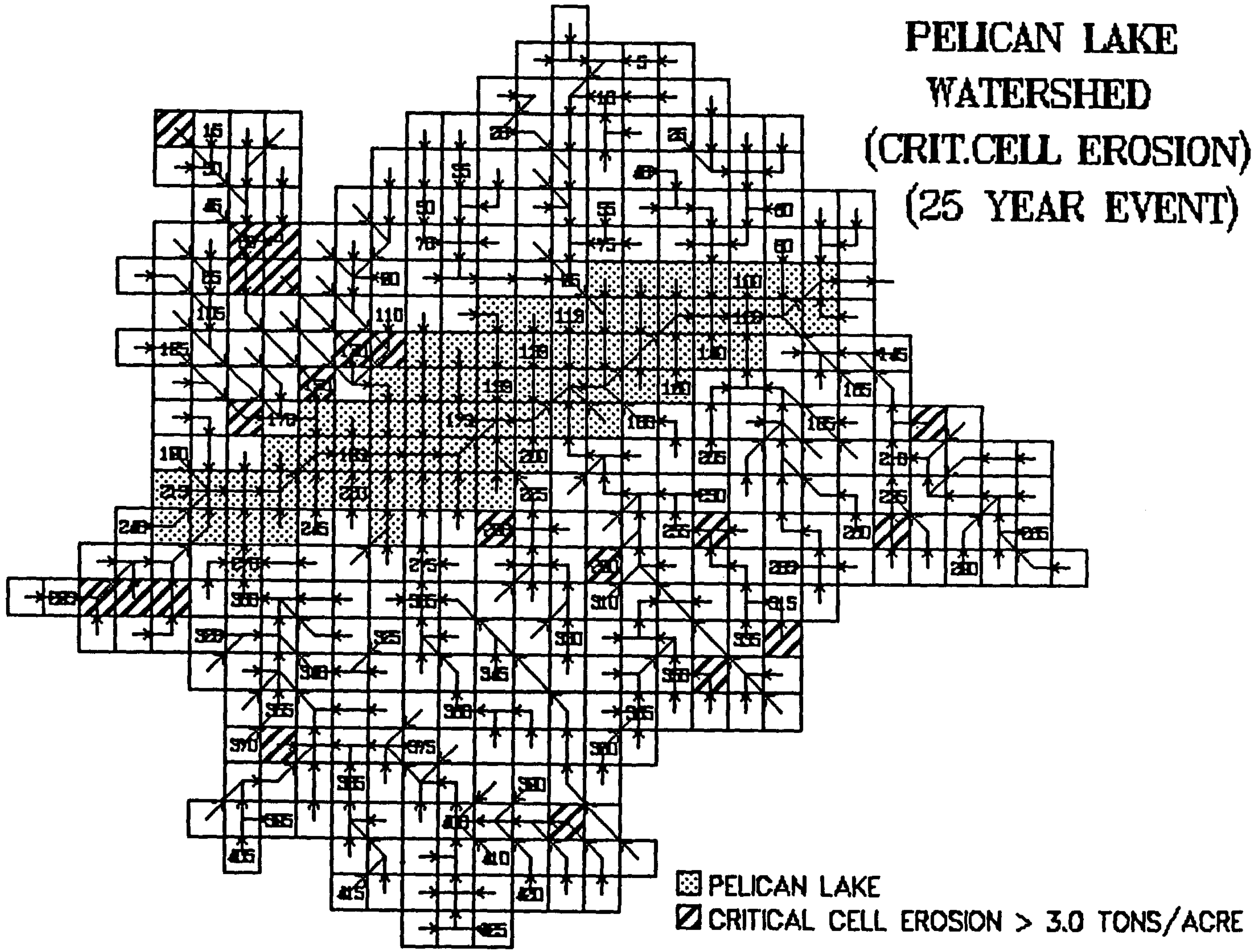




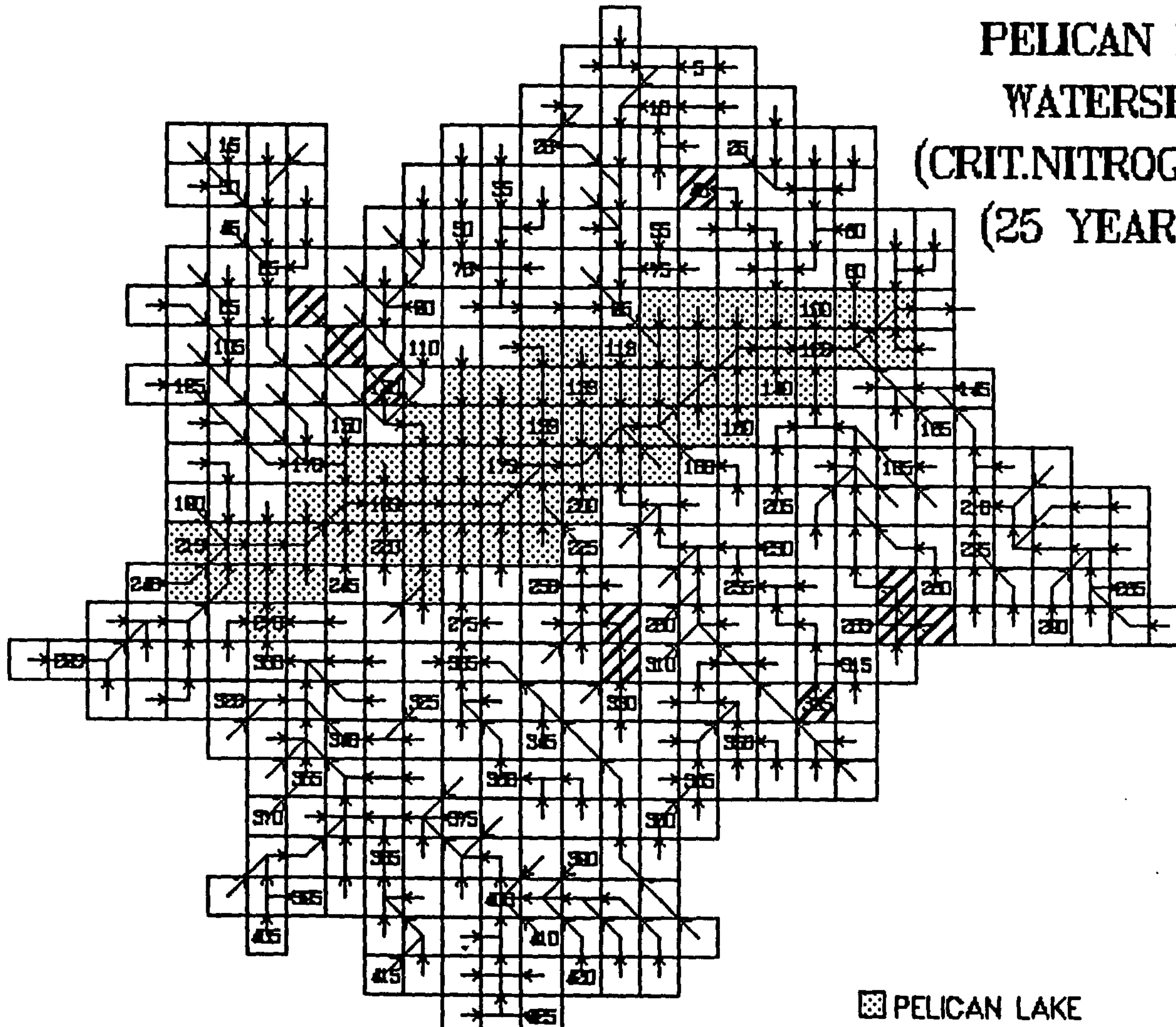
PELICAN LAKE WATERSHED (PHOS. CON.) (25 YEAR EVENT)

PELICAN LAKE
CRITICAL PHOS. CON. > 5.0 ppm

PELICAN LAKE WATERSHED (CRIT.CELL EROSION) (25 YEAR EVENT)

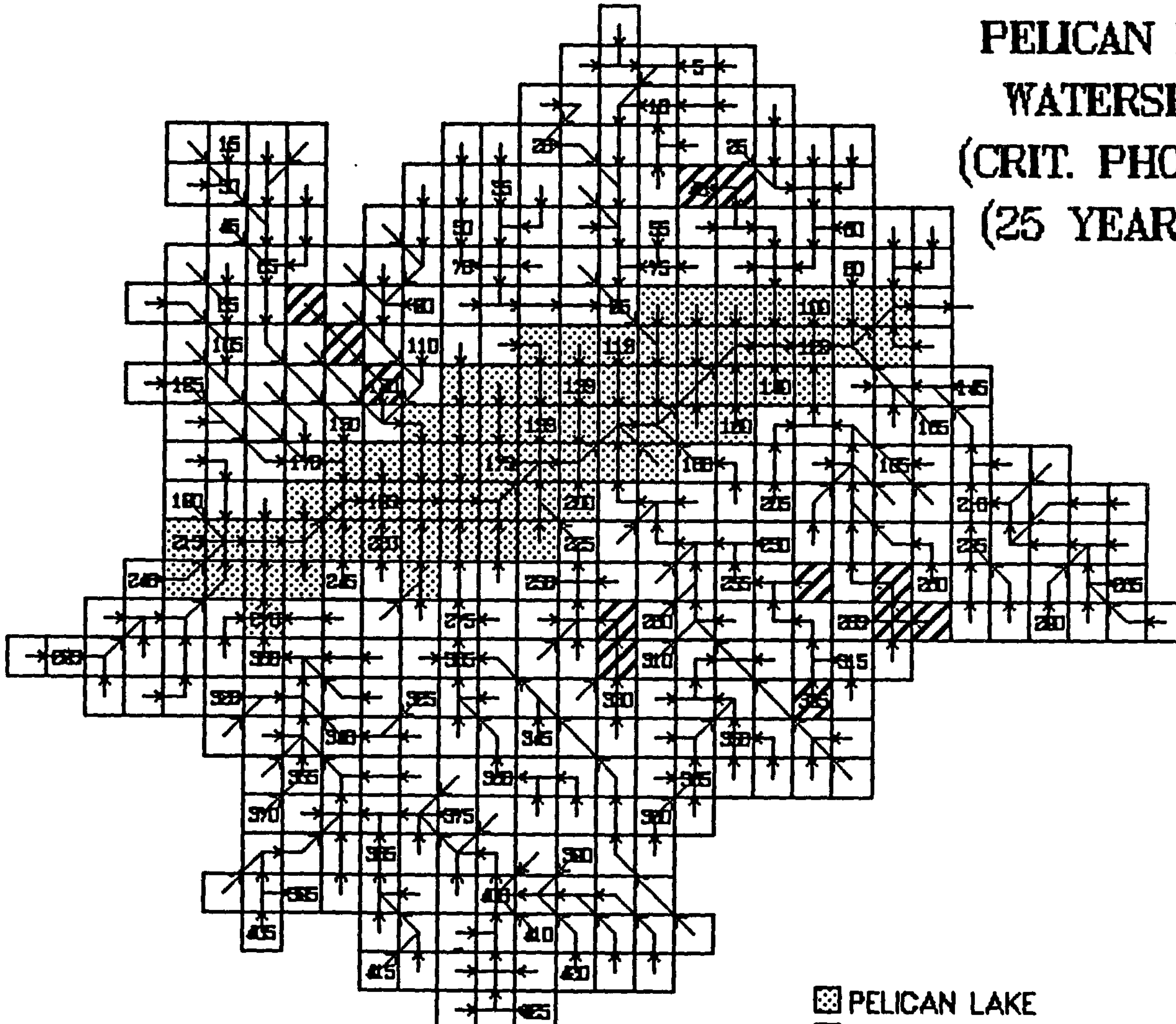


PELICAN LAKE WATERSHED (CRIT.NITROGEN CON.) (25 YEAR EVENT)



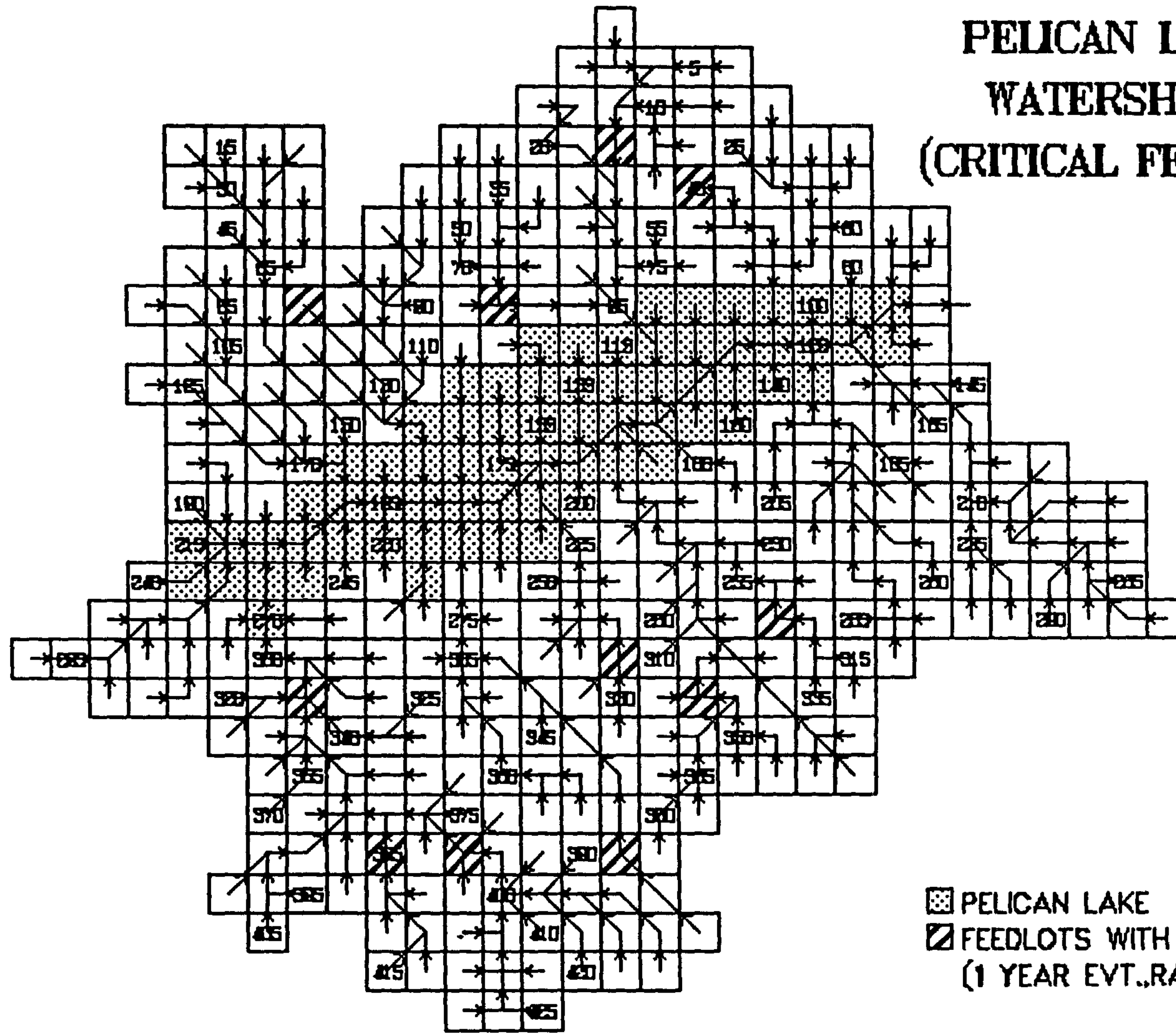
PELICAN LAKE
NITROGEN CON. > 25 ppm

PELICAN LAKE WATERSHED (CRIT. PHOS. CON.) (25 YEAR EVENT)



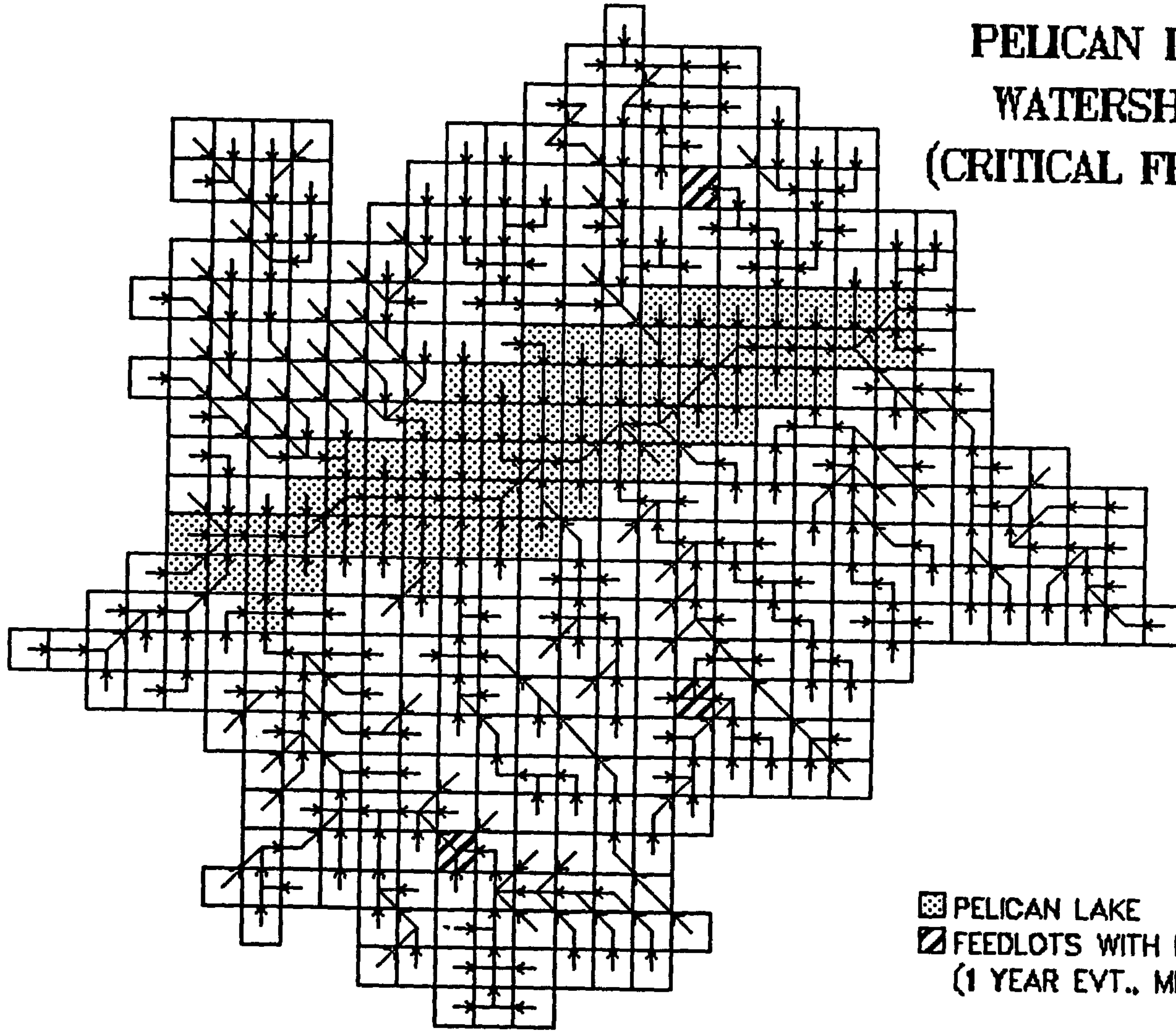
PELICAN LAKE
CRITICAL PHOS. CON. > 5.0 ppm

PELICAN LAKE WATERSHED (CRITICAL FEEDLOTS)



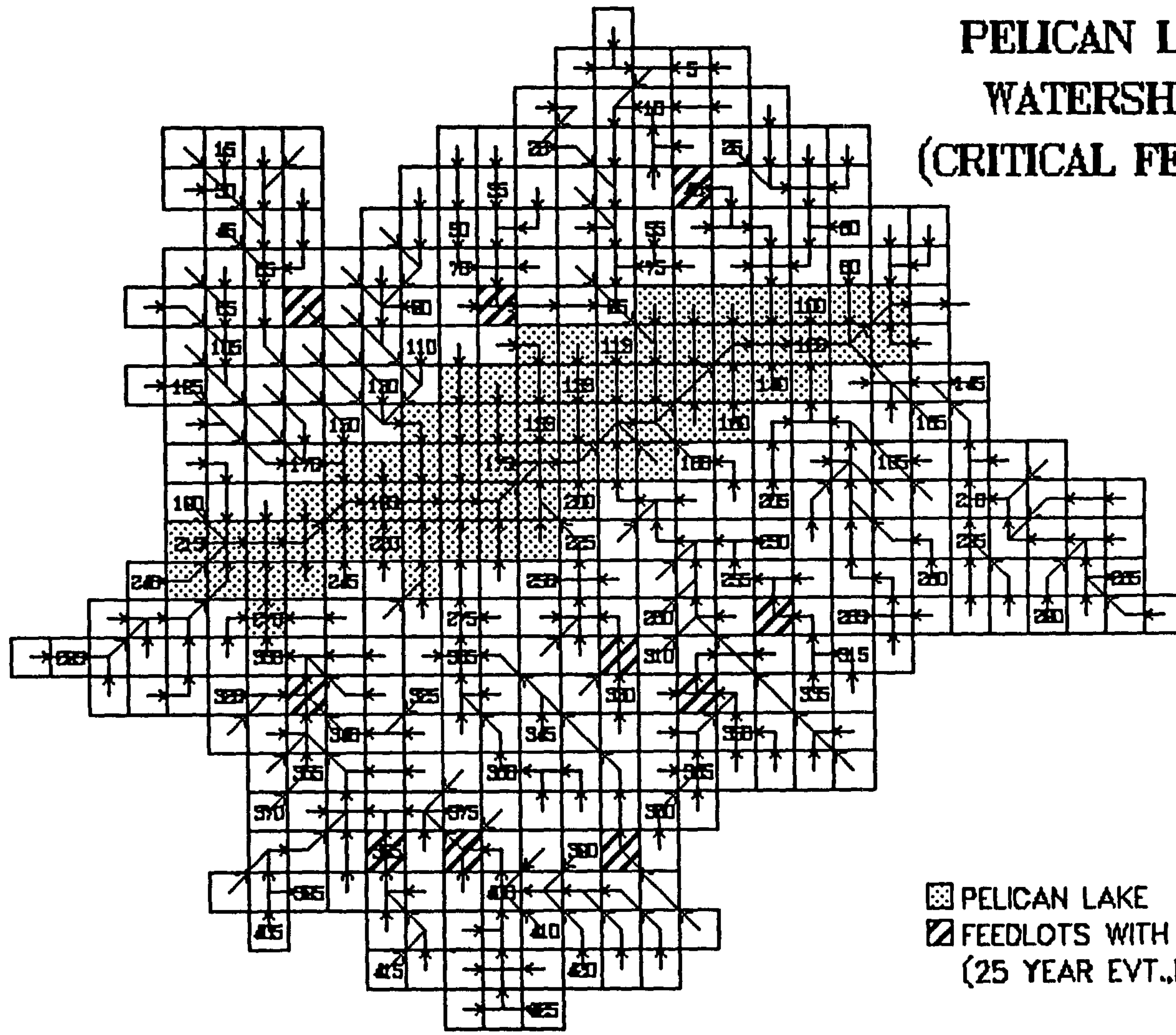
▒ PELICAN LAKE
▨ FEEDLOTS WITH RANK > 22
(1 YEAR EVT.,RANK>MEAN)

PELICAN LAKE
WATERSHED
(CRITICAL FEEDLOTS)



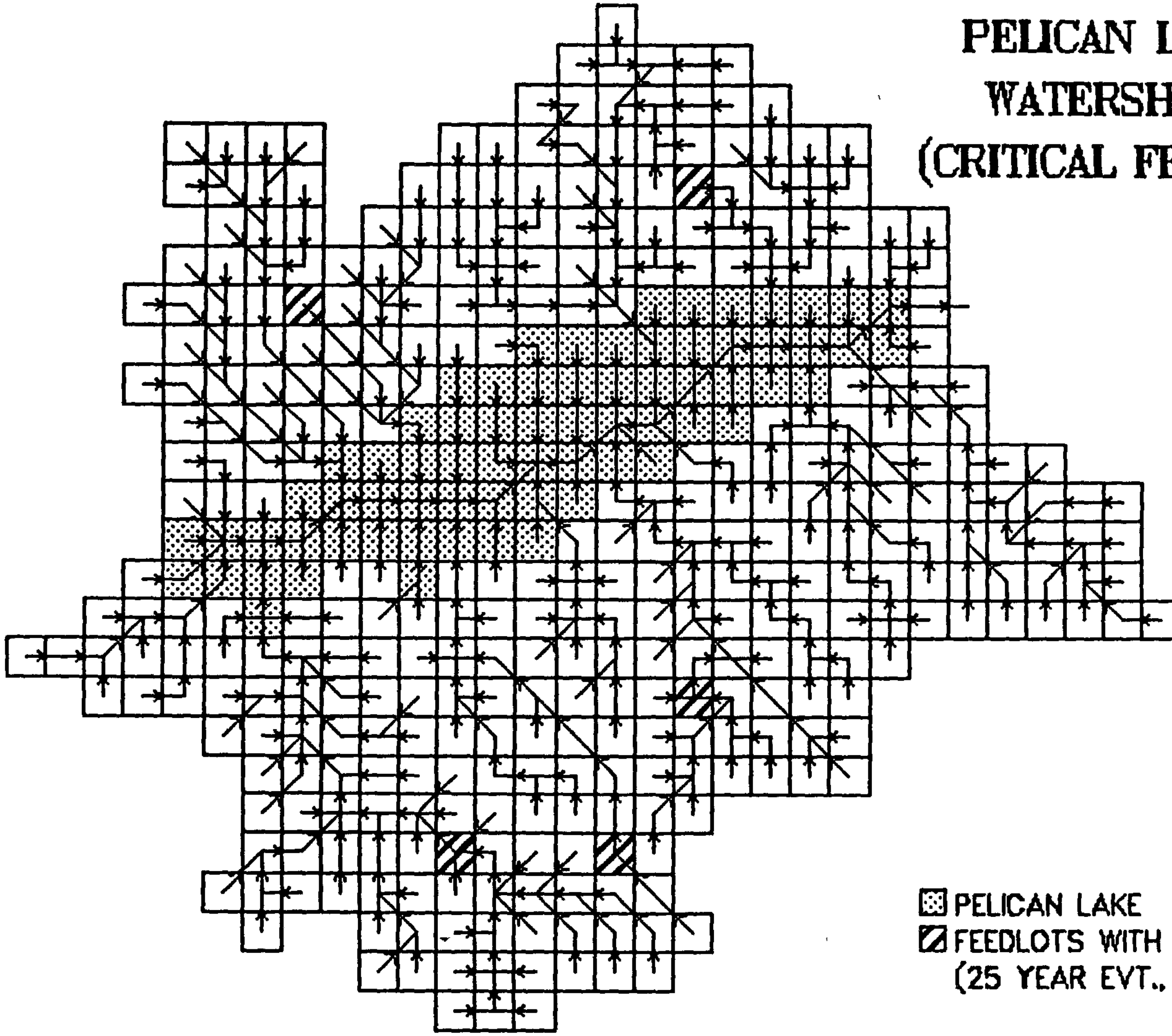
PELICAN LAKE
FEEDLOTS WITH RANK > 41
(1 YEAR EVT., MEAN+1 STDS)

PELICAN LAKE WATERSHED (CRITICAL FEEDLOTS)



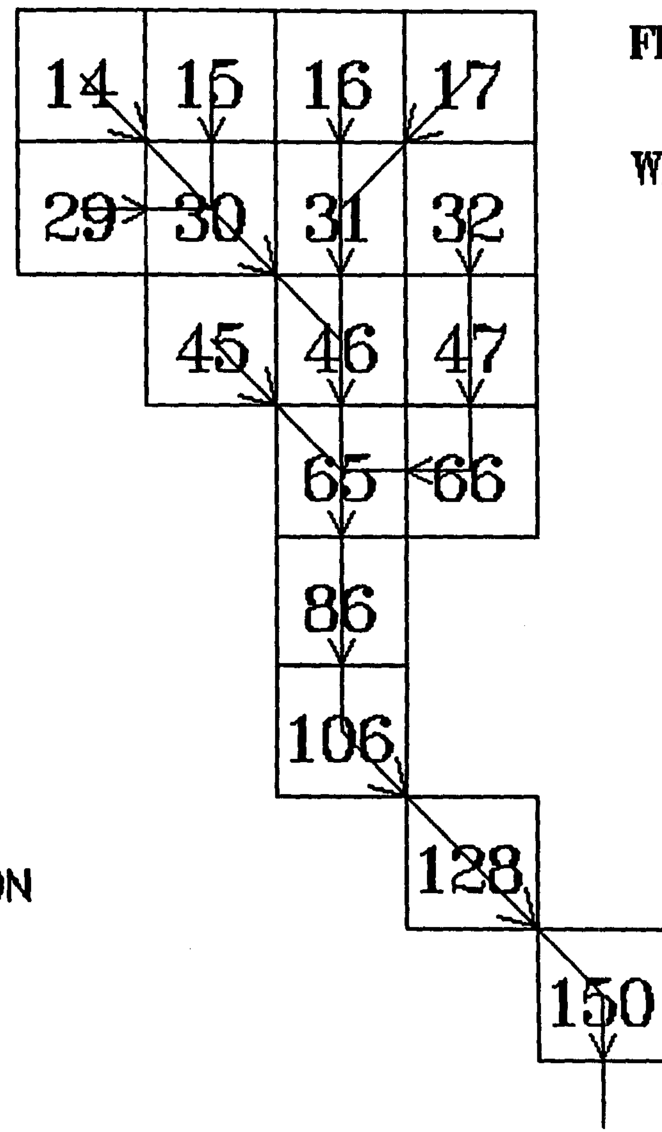
PELICAN LAKE
FEEDLOTS WITH RANK > 34 (25 YEAR EVT.,RANK>MEAN)

PELICAN LAKE WATERSHED (CRITICAL FEEDLOTS)

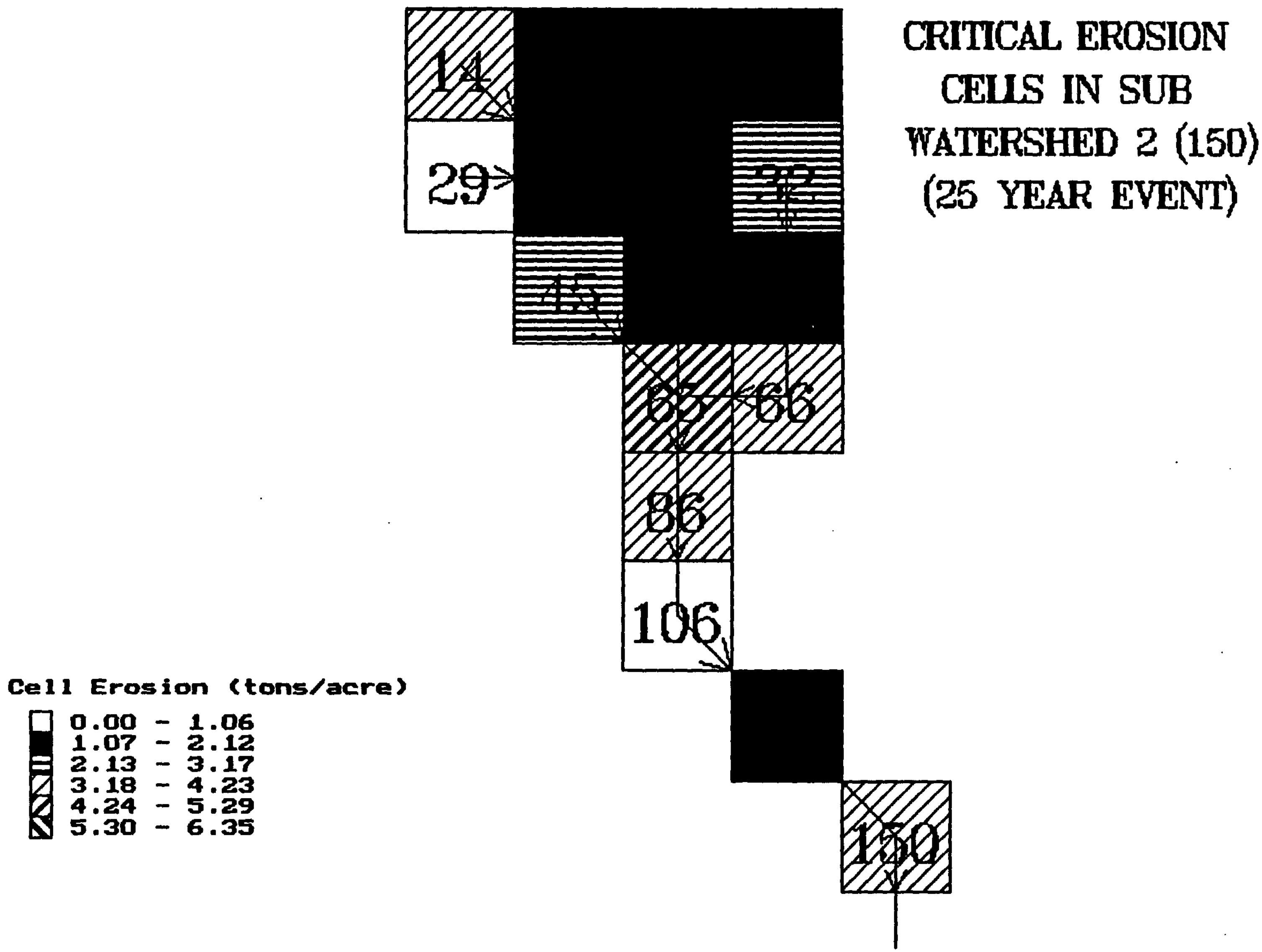


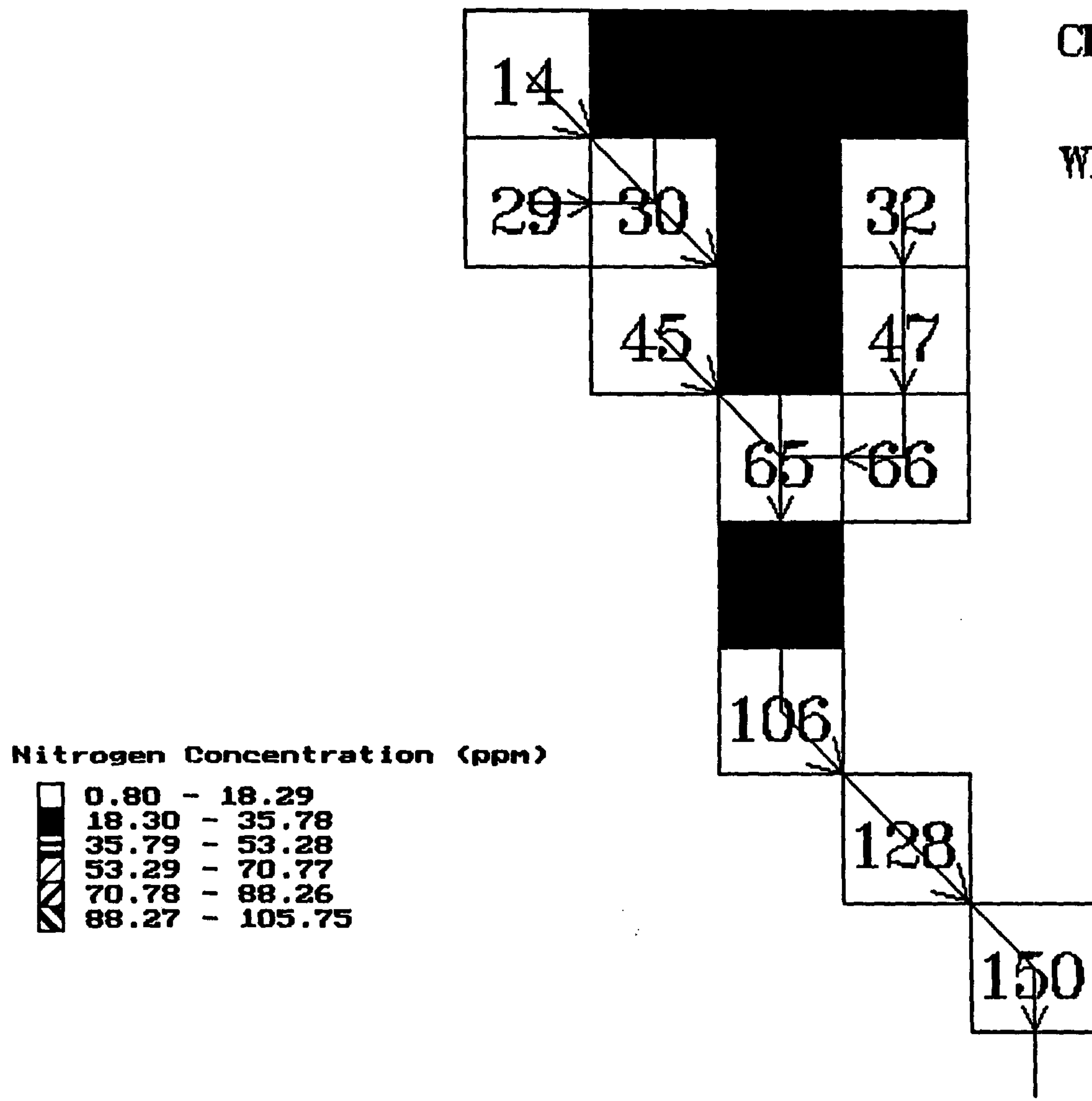
PELICAN LAKE
FEEDLOTS WITH RANK > 52
(25 YEAR EVT., MEAN+1 STDS)

FEEDLOT LOCATION CELLS IN SUB WATERSHED 2 (150) (25 YEAR EVENT)



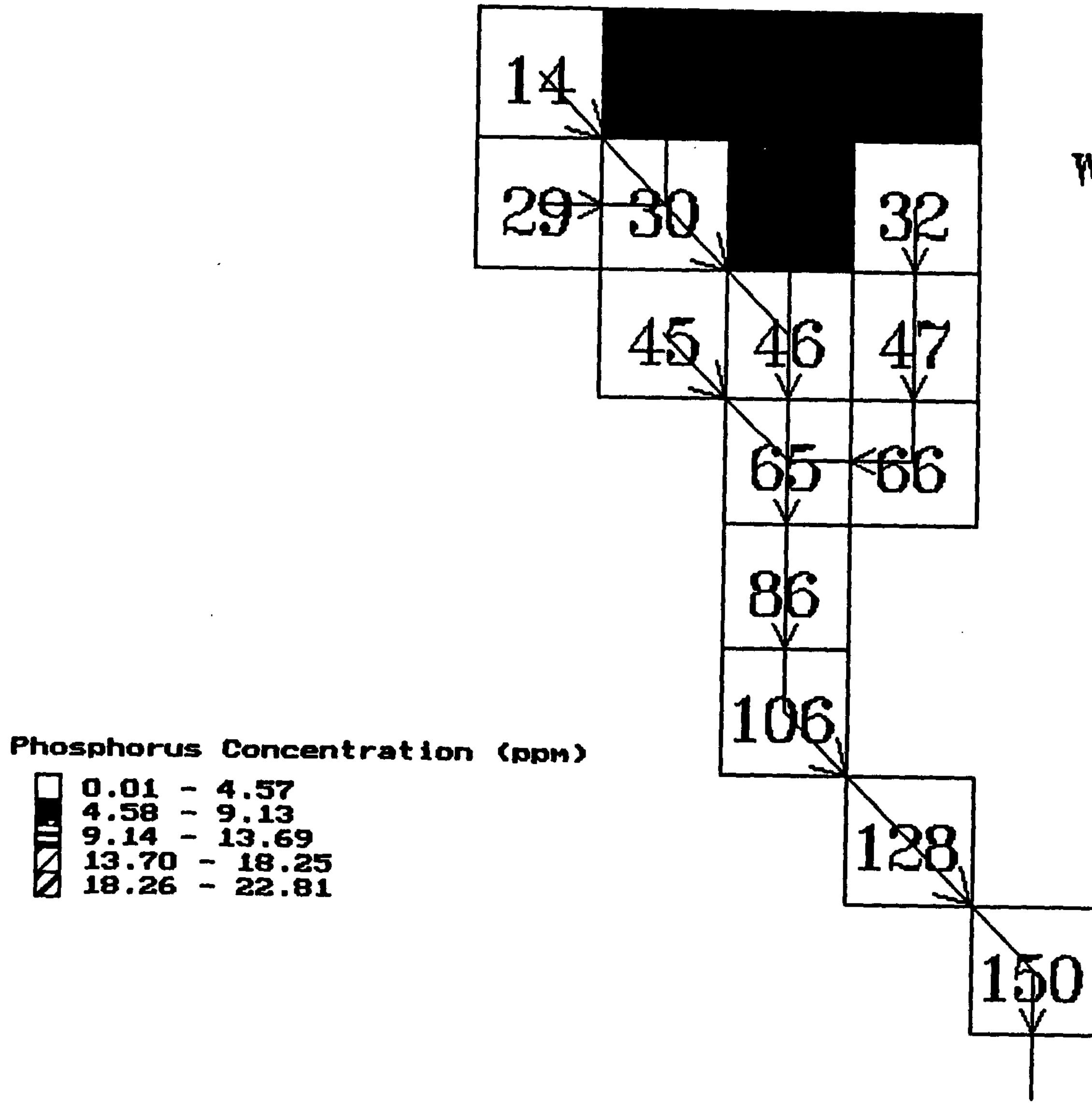
FEEDLOT LOCATION


CRITICAL EROSION
CELLS IN SUB
WATERSHED 2 (150)
(25 YEAR EVENT)
14
29
32
45
65
66
86
106
150
Cell Erosion (tons/acre)
0.00 - 1.06
1.07 - 2.12
2.13 - 3.17
3.18 - 4.23
4.24 - 5.29
5.30 - 6.35

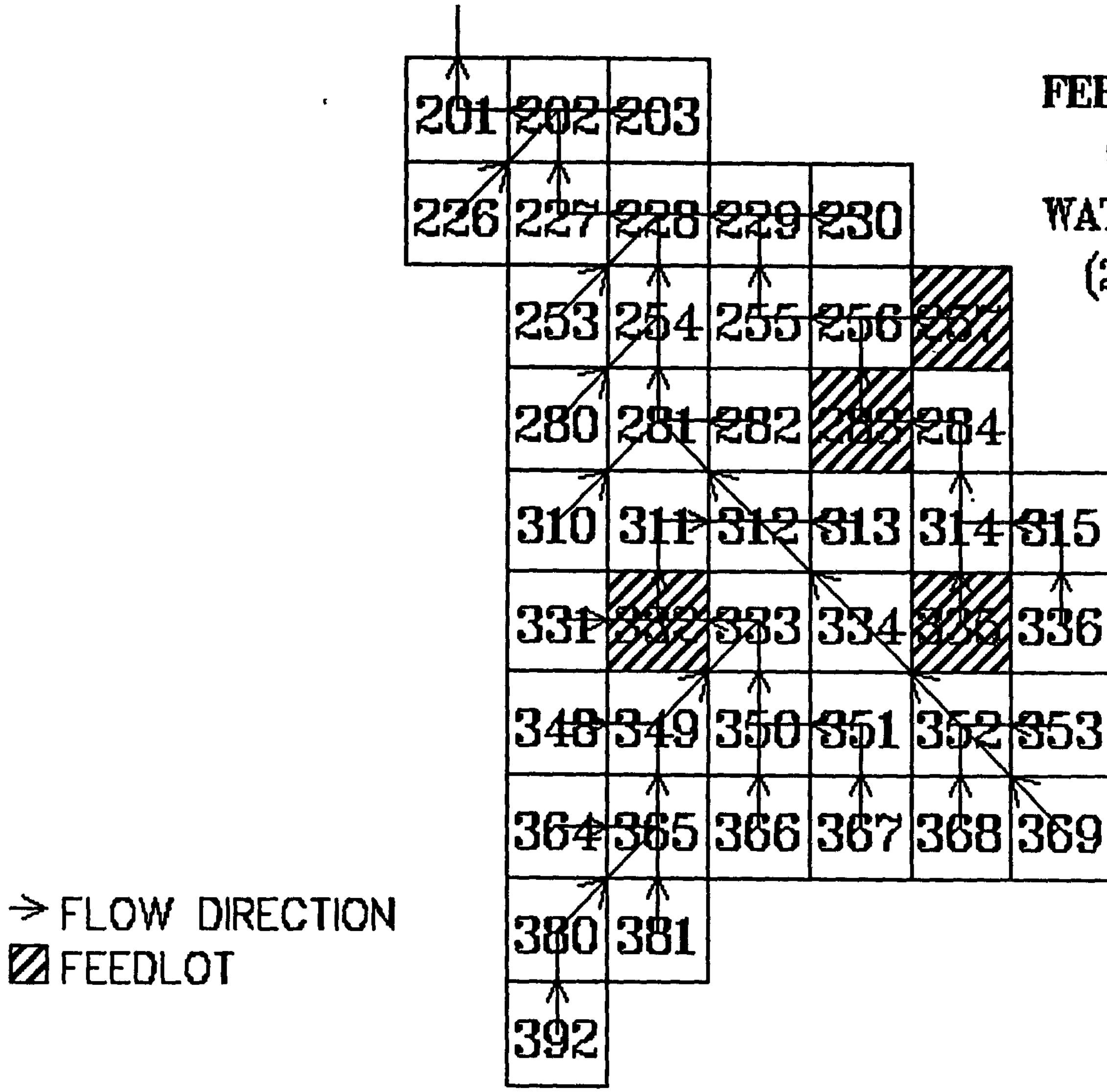


CRITICAL NITROGEN CELLS IN SUB WATERSHED 2 (150) (25 YEAR EVENT)

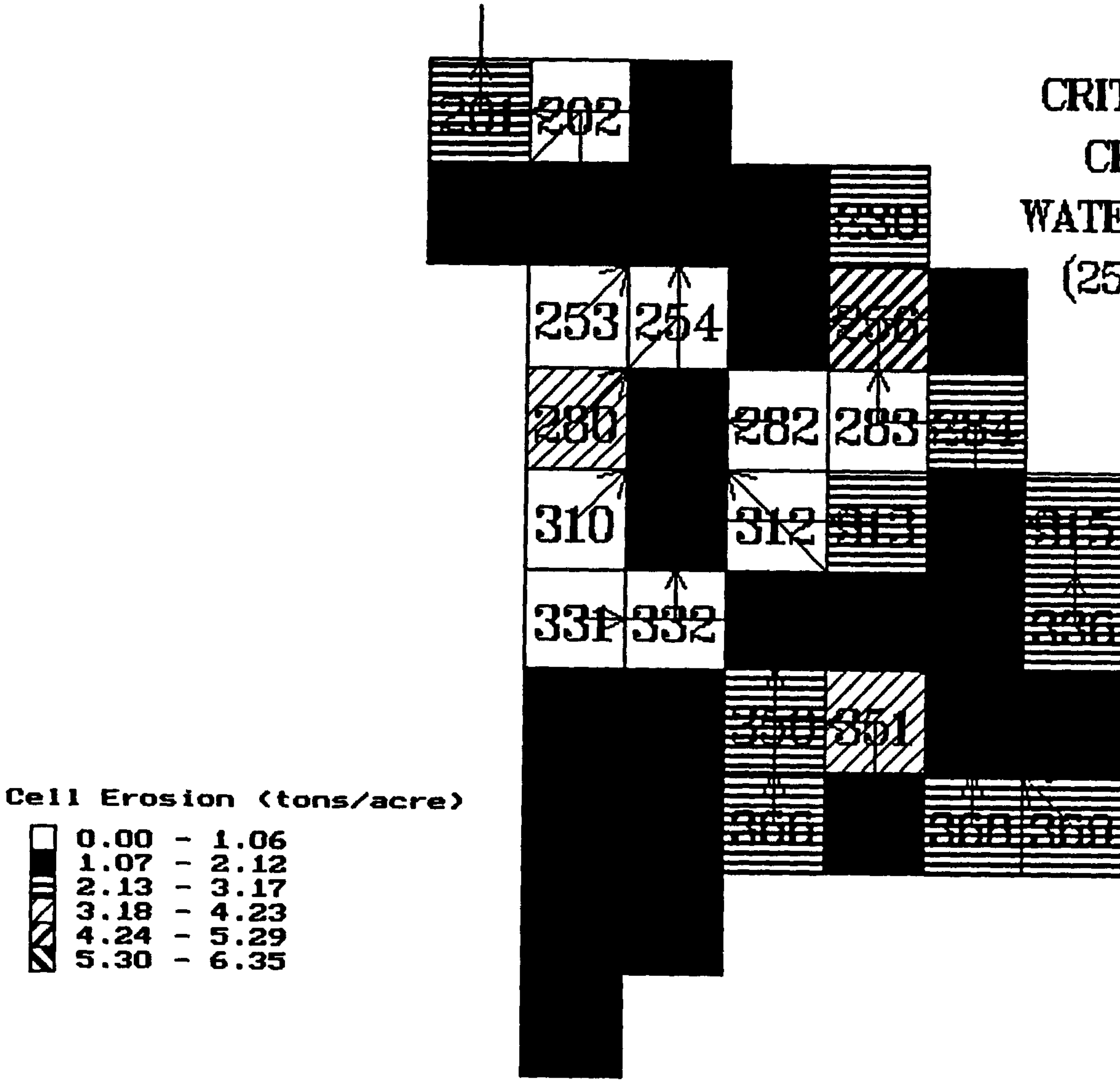
CRITICAL PHOS.
CELLS IN SUB
WATERSHED 2 (150)
(25 YEAR EVENT)



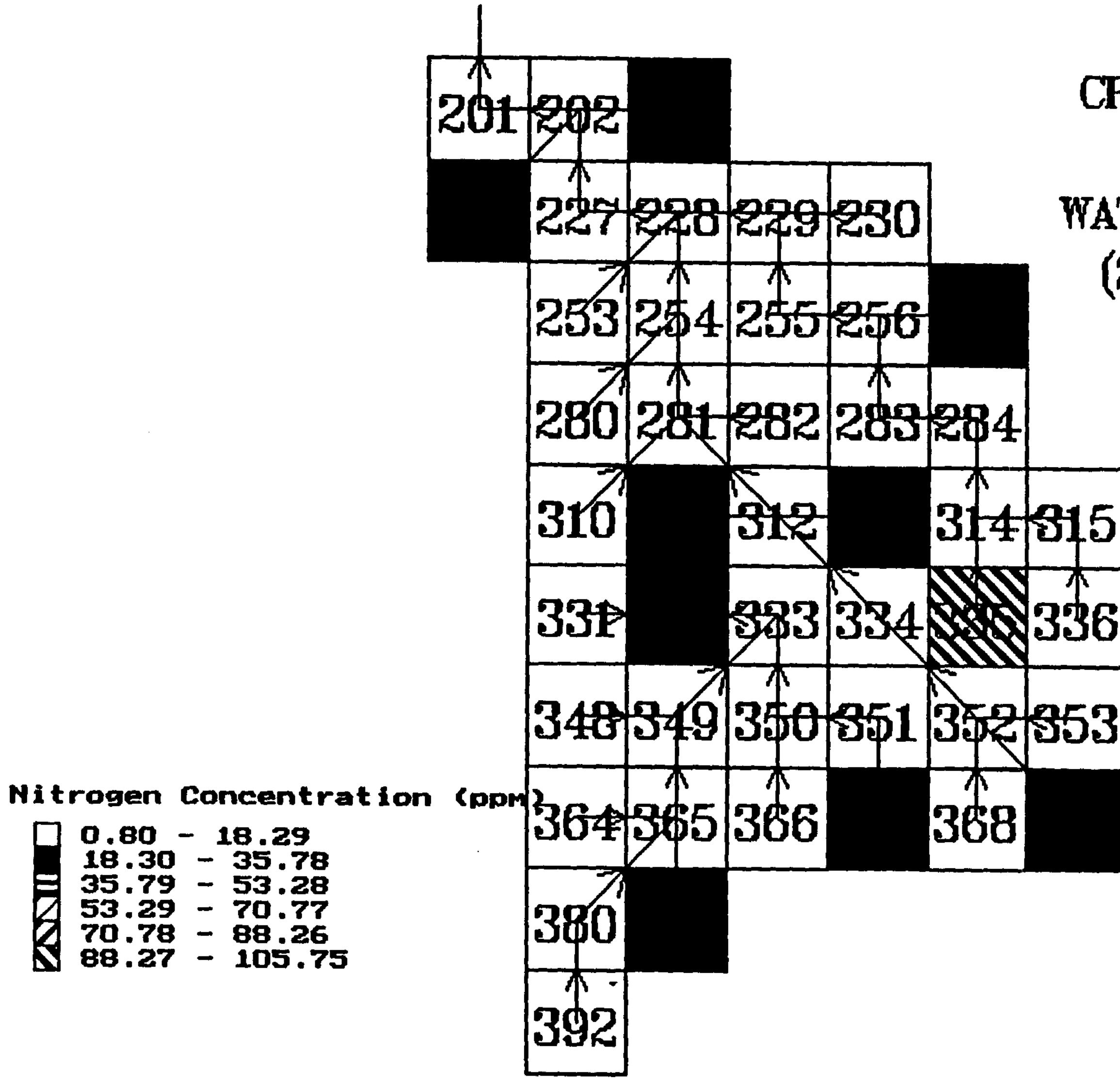
FEEDLOT LOCATION CELLS IN SUB WATERSHED 10 (201) (25 YEAR EVENT)



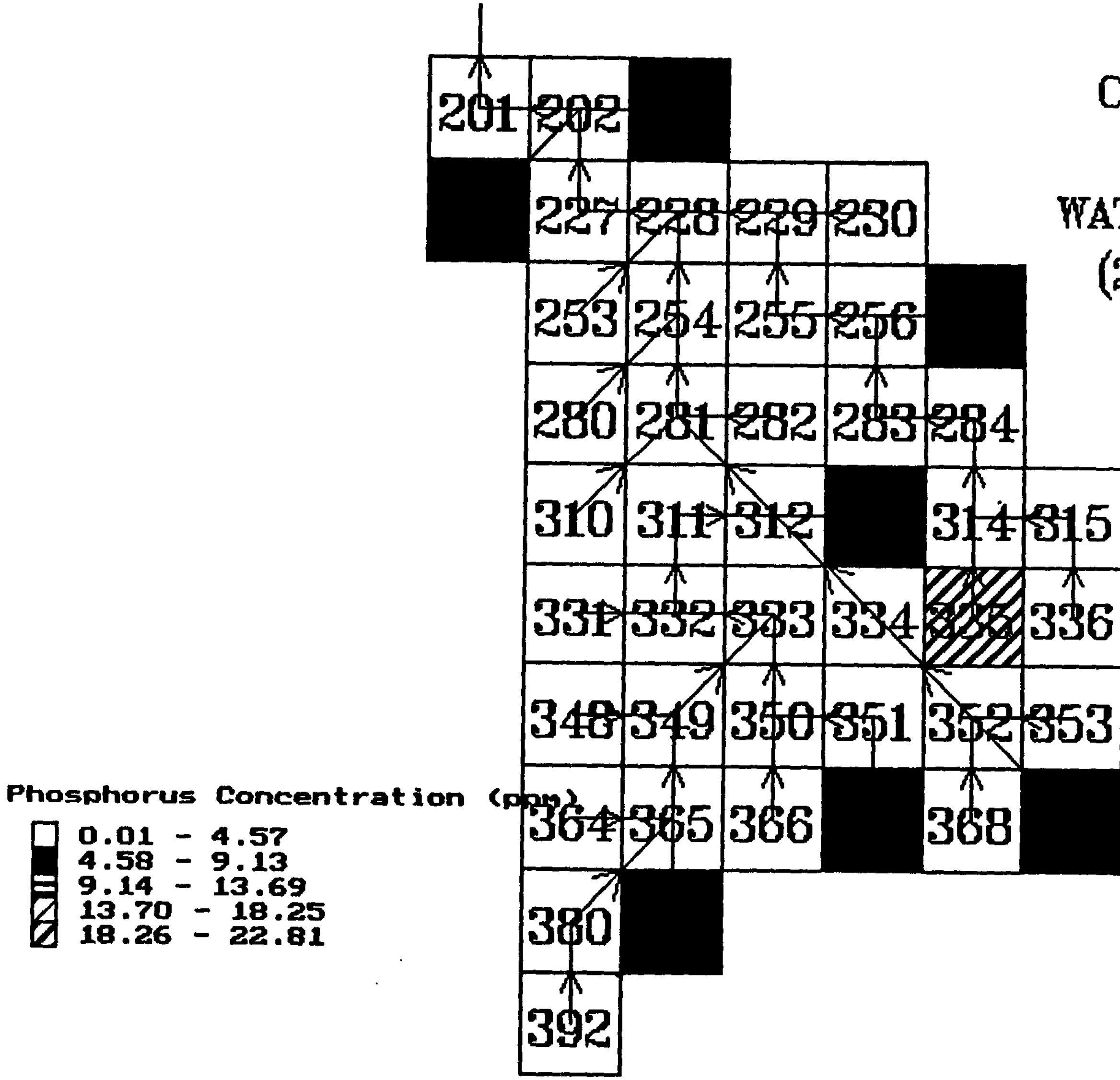
CRITICAL EROSION
CELLS IN SUB
WATERSHED 10 (201)
(25 YEAR EVENT)



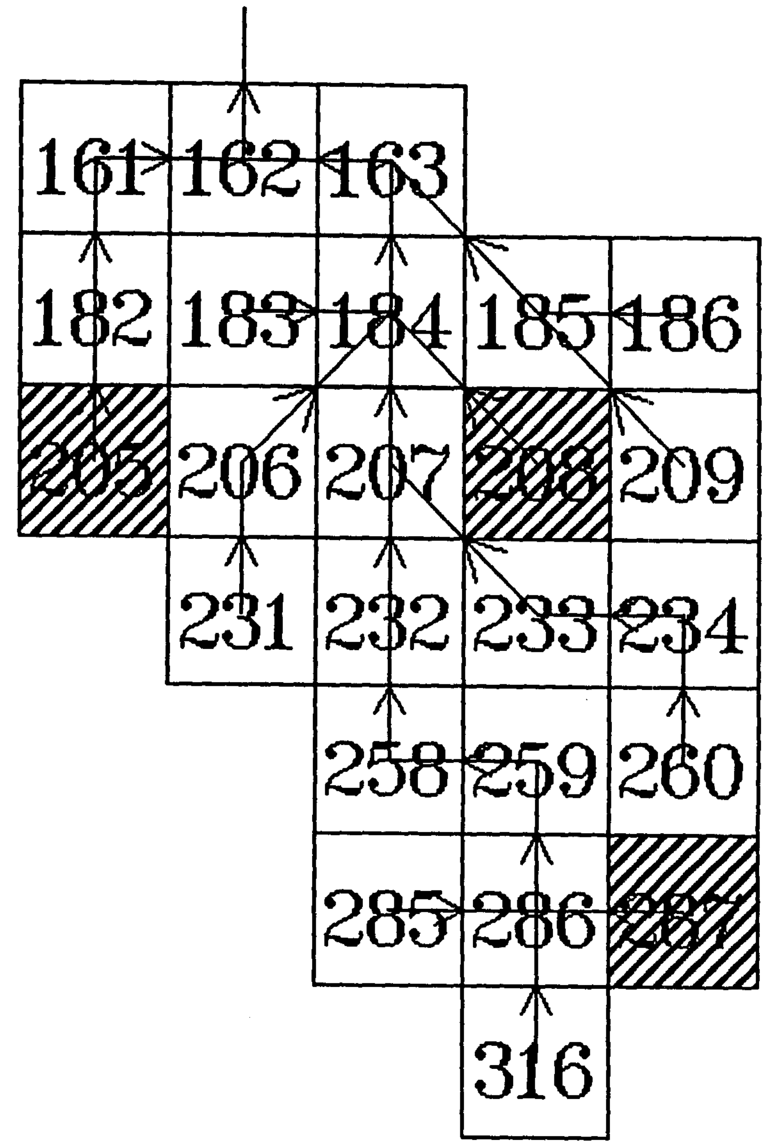
CRITICAL NITROGEN CELLS IN SUB WATERSHED 10 (201) (25 YEAR EVENT)



CRITICAL PHOS.
CELLS IN SUB
WATERSHED 10 (201)
(25 YEAR EVENT)

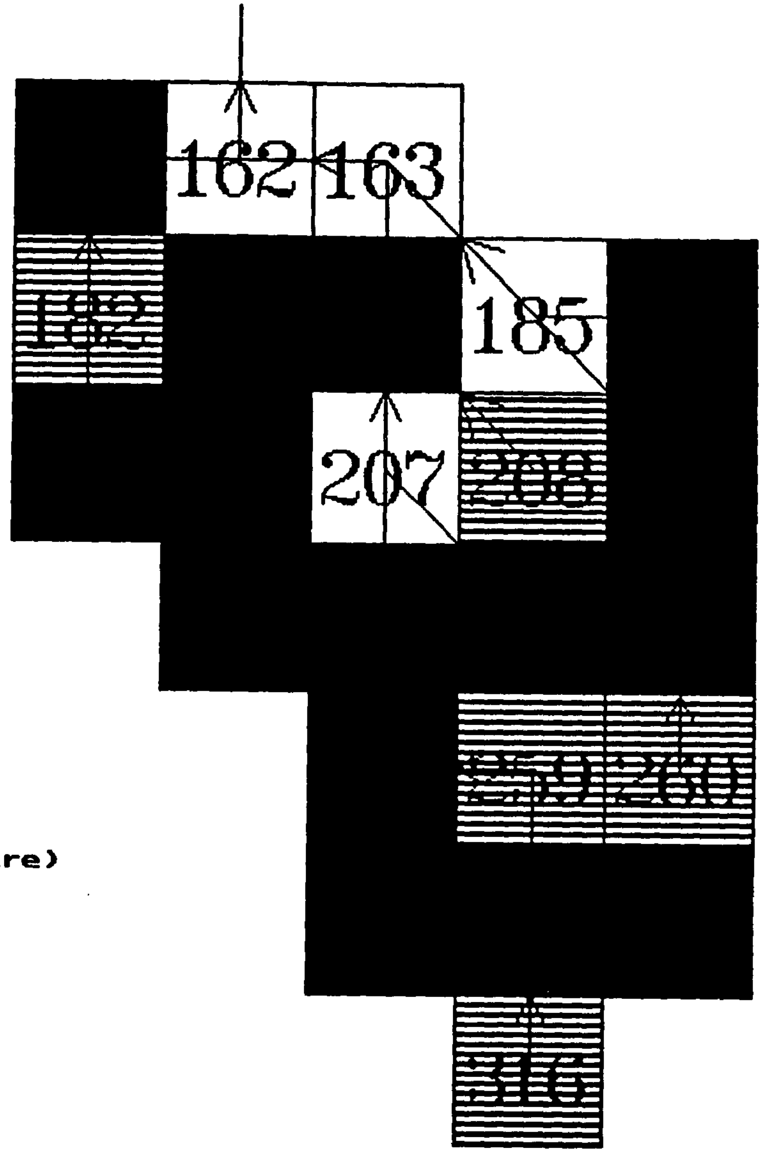


FEEDLOT LOCATION
CELLS IN SUB
WATERSHED 11 (162)
(25 YEAR EVENT)



→ FLOW DIRECTION
▨ FEEDLOT LOCATION

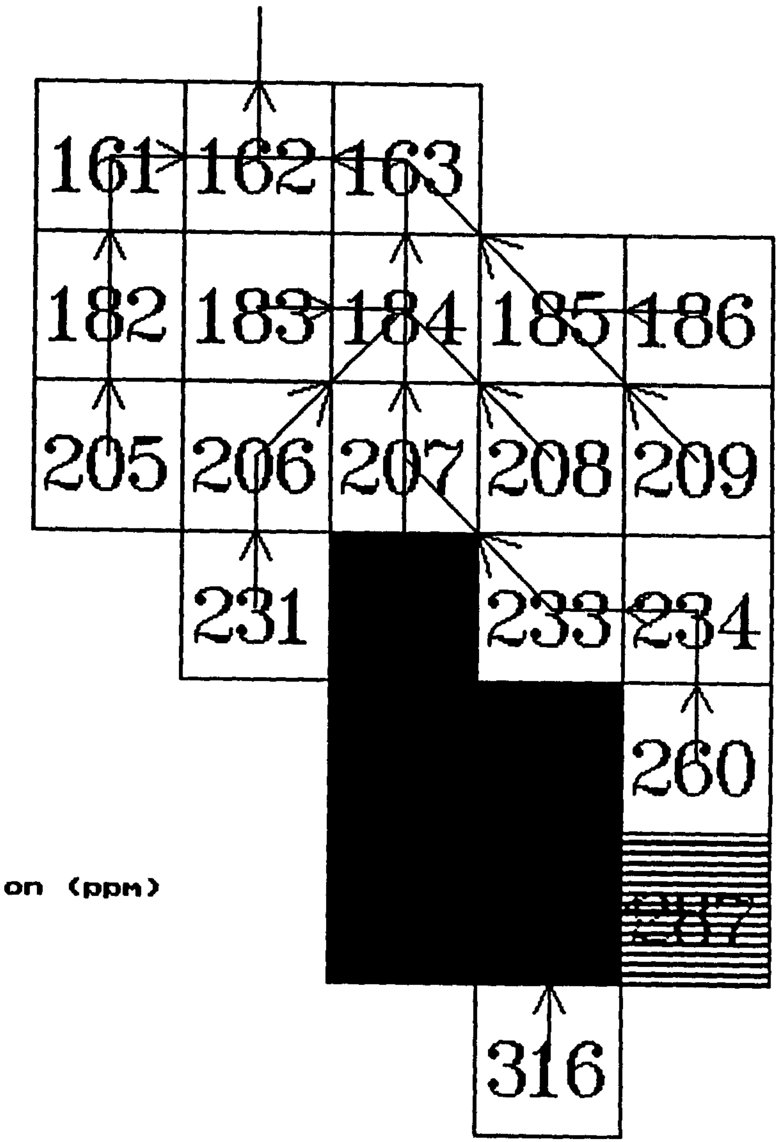
CRITICAL EROSION
CELLS IN SUB
WATERSHED 11 (162)
(25 YEAR EVENT)



Cell Erosion (tons/acre)

- 0.00 - 1.06
- 1.07 - 2.12
- 2.13 - 3.17
- 3.18 - 4.23
- 4.24 - 5.29
- 5.30 - 6.35

CRITICAL NITROGEN
CELLS IN SUB
WATERSHED 11 (162)
(25 YEAR EVENT)

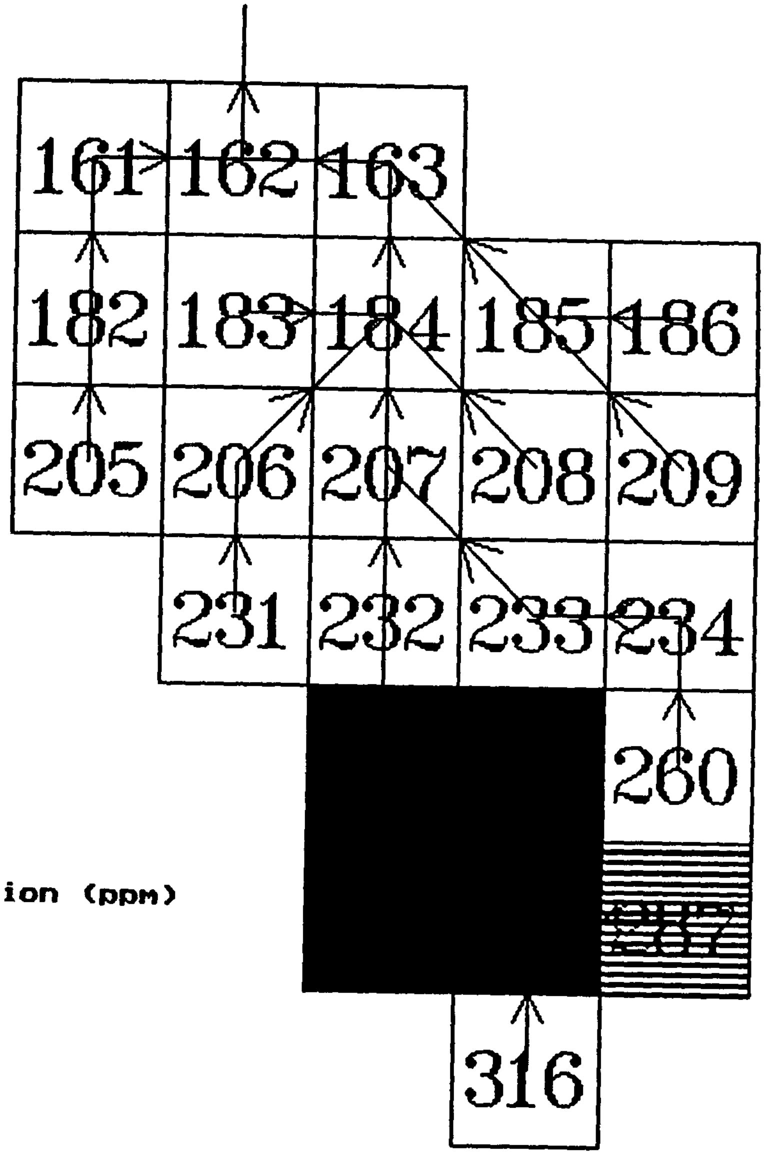


Nitrogen Concentration (ppm)

0.80 - 18.29
18.30 - 35.78
35.79 - 53.28
53.29 - 70.77
70.78 - 88.26
88.27 - 105.75

98

CRITICAL PHOS.
CELLS IN SUB
WATERSHED 11 (162)
(25 YEAR EVENT)

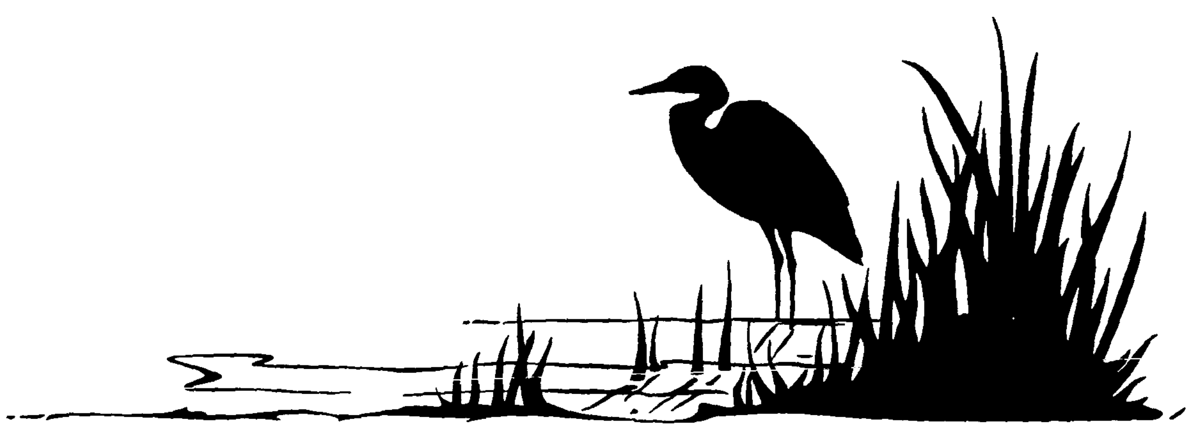


Phosphorus Concentration (ppm)

- 0.01 - 4.57
- 4.58 - 9.13
- 9.14 - 13.69
- 13.70 - 18.25
- 18.26 - 22.81

APPENDIX C.

SOILS AND GROUND WATER HYDROLOGY



UPPER BIG SIOUX RIVER WATERSHED--SOILS CLASSIFICATIONS

1. Brookings-Kranzburg-Vienna Association
These soils are well-drained, nearly level to gently undulating, silty soils formed in loess and loamy glacial till. In this association are soils on broad ridgetops and on long, smooth side slopes that end along drainageways. The drainageways empty into the Big Sioux River and its tributaries. The long, smooth slopes of this soil association are well suited to contour farming, contour stripcropping, and terracing, which can help to control runoff and erosion.

2. Estelline-Fordville-Renshaw Association
Soils in this association are well-drained, nearly level to gently sloping, medium-textured and moderately coarse textured soils underlain by sand and gravel. These soils are found on stream terraces and outwash plains. Conserving water and controlling wind erosion are major problems on these soils.

3. Lamoure-Rauville Association
This association consists of soils on the bottomlands of the Big Sioux River and its tributaries. These moderately fine textured soils are nearly level, somewhat poorly drained to very poorly drained, and occasionally flooded.

4. Poinsett-Buse-Parnell Association
A small amount of the soils in the Upper Big Sioux River watershed are of the Poinsett-Buse Association. Soils in this association are well-drained, undulating to rolling silty and loamy soils.

5. Poinsett-Waubay-Oldham Association
Soils in this association are nearly level or gently undulating and moderately fine to medium textured. Water which collects in these soils forms sloughs and lakes in closed depressions.

6. Vienna-Lismore
The soils in this association are deep and moderately well-drained, level to strongly sloping when adjacent to entrenched drainways. They are silty soils usually occurring in upland areas.

7. Renshaw-Fordville-Divide Association
This association consists of soils that are somewhat excessively drained to poorly drained, and that are nearly level to moderately steep. They are shallow to moderately deep, occurring over sands and gravels on upland areas and terraces.

8. LaDelle-Dovray-Playmoor
Soils of this association are deep, moderately to poorly drained, and level to nearly level. They are composed of soils that are silty with intermittent clay that occur on flood plains, low terraces, and upland flats.

9. Renshaw-Fordville
This association is made up of somewhat excessively to well-drained soils which occur in nearly level to steep areas. The soils in this association are shallow to moderately deep occurring over outwash sand and gravel.

10. Vienna
This association occurs mainly in the northern reaches of the Big Sioux River watershed in areas of well-drained, nearly level to sloping soils. Soils of this association are silty and formed in loess and glacial till.

11. Forman-Buse-Parnell
This association is found in areas of undulating to rolling formations. Soils are medium to moderately fine textured, and are formed from clay loam and glacial till.

12. Buse-Barnes
This association is composed of loamy soils that are well drained, and rolling to steep. These soils are found primarily on moraines.

IMMEDIATE PELICAN LAKE WATERSHED--SOILS CLASSIFICATIONS

1. Poinsett-Waubay-Oldham Association
Soils in this association are nearly level or gently undulating and moderately fine to medium textured. Water which collects in these soils forms sloughs and lakes in closed depressions.

2. Estelline-Fordville-Renshaw Association
Soils in this association are well-drained, nearly level to gently sloping, medium-textured and moderately coarse textured soils underlain by sand and gravel. These soils are found on stream terraces and outwash plains. Conserving water and controlling wind erosion are major problems on these soils.

3. Poinsett-Buse-Parnell Association
A small amount of the soils in the Pelican Lake watershed are of the Poinsett-Buse Association. Soils in this association are well-drained, undulating to rolling silty and loamy soils.

4. Brookings-Kranzburg-Vienna Association
These soils are well-drained, nearly level to gently undulating, silty soils formed in loess and loamy glacial till. In this association are soils on broad ridgetops and on long, smooth side slopes that end along drainageways. The drainageways empty into the Big Sioux River and its tributaries. The long, smooth slopes of this soil association are well suited to contour farming, contour stripcropping, and terracing, which can help to control runoff and erosion.

5. Forman-Buse-Parnell Association
This association is found in areas of undulating to rolling formations. Soils are medium to moderately fine textured, and are formed from clay loam and glacial till.

6. Buse-Sioux Association
This association is found in steep or rolling glacial moraine. The soils of this association are formed in glacial drift, or gravelly glacial outwash.

7. Lamour-Rauville Association
This association consists of soils on the bottomlands of the Big Sioux River and its tributaries. These moderately fine textured soils are nearly level, somewhat poorly drained to very poorly drained, and occasionally flooded.

HYDROLOGY OF PELICAN LAKE WATERSHED BASIN

Hydrology of a lake may be defined as the study of factors controlling the quality and processes governing the depletion and replenishment of the water in a lake. It takes into consideration precipitation, evaporation, flow into and out of the lake from both surface and subsurface, and the effects of artificial control. Hydrology of a lake is a science by which the behavior of lakes may be analyzed.

The water level of a lake is a function of the volume of water contained in the lake basin. The rate of change of water volume is controlled by the rate at which water enters the basin from all sources, minus the rate at which water is lost. Recharge to a lake includes water from all sources, and may be divided into three major categories: 1) direct precipitation, 2) ground water recharge, and 3)surface water recharge.

Direct Precipitation : The term precipitation, as used in hydrology, is a general term for all forms of water derived from atmospheric vapor deposited on a lake surface. Precipitation received in the Pelican Lake area is measured at the U.S. Weather Bureau Station at the Watertown Airport. The records show that the average annual precipitation at this station for the years 1898-1970 is 20.52 inches.

Ground Water Recharge: Ground water is defined as water contained in the voids of openings of rocks or sediments below the water table. The water table is the upper surface of the zone of saturation which is under atmospheric pressure. Practically all the pores of permeable rocks that lie below the water table are filled with water. Rocks (including the soil) that lie above the water table are in the zone of aeration. Some of the interstices in this zone are also filled with water, but the water is either held by molecular attraction or is moving downward toward the zone of saturation. Water in the ground moves downward through the unsaturated zone under the influence of gravity, whereas in the saturated zone it moves in a direction determined by the hydraulic gradient.

Nearly all ground water is derived from precipitation in the form of rain, melting snow, or ice. Water from these sources either evaporates, percolates directly downward to the water table and becomes ground water, or drains off as surface water. Surface water either evaporates, escapes to lakes or oceans by streams, or percolates downward into rocks.

Recharge is the addition of water to an aquifer, which is a formation having structures that permit appreciable amounts of water to move through it under ordinary field conditions. Recharge is accomplished in four main ways: 1) by downward percolation of precipitation from the ground surface, 2) by downward percolation from surface bodies of water, 3) by lateral flow of ground water into an area, and 4) by artificial recharge, which takes place from excess irrigation, seepage from canals, and water purposely applied to augment ground water supplies.

Discharge of ground water from an aquifer is accomplished in four main ways: 1) by evaporation from free-water surfaces and transpiration by plants, 2) by seepage upward or laterally into surface bodies of water, 3) by lateral movement of water out of the area, and 4) by pumping from wells. Pumping from wells constitutes the major artificial discharge of ground water.

Surface Water Recharge: Precipitation in the form of melting snow or rain reaching the ground surface becomes either surface runoff or infiltration, depending on whether or not the rain intensity exceeds the infiltration capacity. At Pelican Lake, surface water flows into the lake through the inlet/outlet channel whenever the water level in the Big Sioux River is higher than the lake level.

Discharge: discharge from a lake includes all water leaving the lake. This can be divided into 1) evapotranspiration, 2) surface water discharge, 3) ground water discharge, and 4) artificial discharge.

Evapotranspiration: All water, surface and subsurface, released into the atmosphere by processes of evaporation and transpiration is called evapotranspiration. Transpiration is the process whereby the moisture that has circulated through a plant structure is returned to the atmosphere, principally in the form of water vapor. The rate of transpiration depends on climate and type of vegetation.

Evaporation is the process by which a liquid (water) is changed into vapor. The evaporation process occurs from the surface of land, lakes, ponds, and streams. Depth has a pronounced influence upon the rate of evaporation from any body of water. Likewise, water from a soil surface will evaporate initially at quite a high rate, but as soon as a thin layer of soil dries out the rate of evaporation is considerably reduced.

Surface Water Discharge: The only surface water discharge from Pelican Lake is by means of the inlet/outlet channel. Water flows to the Big Sioux River when the water level in the lake is higher than the water level in the river northeast of the lake.

Ground Water Discharge: The main groundwater discharge takes place through the sand and gravel deposits east of the lake. Because of the exchange between ground water and surface water in this location, the quantity of each flow could not be estimated accurately with the available data.

Artificial Discharge: Water is pumped by domestic wells from sand and gravel deposits around Pelican Lake. Most of the water pumped for private use is directly or indirectly returned to the lake or to the aquifer around the lake.

Note: The following information was researched from documents published by the South Dakota Geological Survey. The referenced documents are Hydrology of Lake Kampeska (Barari, 1971), and Water Supplies and Geology of Lake Kampeska (Rothrock, 1933).

The water resources of Pelican Lake include three main gravel channels which furnish the majority of the recharge to the lake. One source which enters Pelican Lake from the north originates one mile west of Medicine Lake. This channel, six miles (9.66 km) in length and averaging two miles (3.22 km) in width, contains a large amount of sand and gravel in which rainwater sinks readily and slowly moves southeastward into Lake Kampeska and ultimately into Pelican Lake. A second channel follows the present Big Sioux River, and originates in lower Roberts County in the vicinity of Summit. Five miles (8.05 km) north of Lake Kampeska a side channel with an area of five square miles or more joins the Big Sioux channel. It may possibly extend further west as the valley it occupies can be traced past Florence where it is also gravel filled. A third channel enters the junction from the east following the course of Mud (Gravel) Creek. These gravels were evidently furnished by ice which lay in the vicinity of Punished Woman's Lake during the Pleistocene epoch of geologic time. At the mouth of this narrow channel, gravels were spread over an area of approximately fifteen square miles and joined the gravels of the other two channels a mile (1.61 km) southeast of Rauville. As the slope of these gravel deposits is southward, all water collecting in these channels eventually runs into the junction at Lake Kampeska. These channels recharge Pelican Lake through springs at the northeast end of the lake. When the water levels in the gravels reach a certain point, they raise the lake level to correspond to the level of water in the channels. Because of an extensive connection between the surface and ground water northeast of the lake, the quantity of ground water and surface water recharge cannot be differentiated. No channels enter the lake from the southwest as it is surrounded by long clay slopes which rise westward for a distance of a mile and a half (2.4 km). Although water can enter the lake through a channel which extends to the southeast, this area usually allows for the discharge of lake water through its large gravel beds.

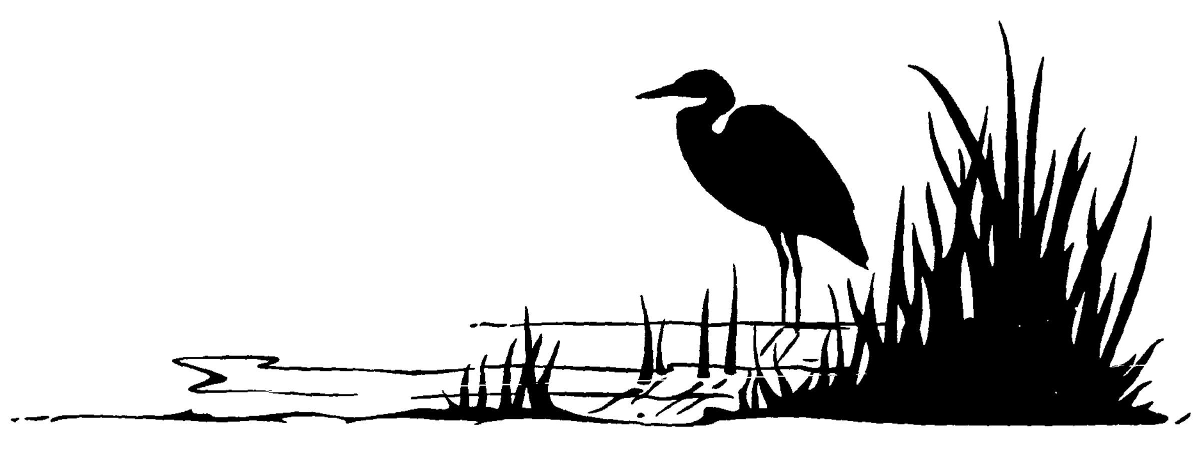
Surface water recharge to the lake is accomplished through the Big Sioux River inlet/outlet located in the northeastern reach of the lake, as well as three intermittent tributaries along the south shore of the lake. Primary recharge occurs mainly during the spring when large amounts of water flow down the Big Sioux River. This results in the lake filling to capacity. Later water is diverted downstream as the lake and river levels stabilize. This causes a portion of the lake water to flow out, allowing the lake level to stabilize with the decreased level of the river. During periods of normal runoff, the flow into and out of the lake is also dependent upon ground water discharge as well as wind driven gradients across the lake. Wind gradients can force water out of, or allow water to enter, the lake on a very small scale (approximately 0.5 cubic feet per second).

Natural discharge from Pelican Lake is dependent upon the level of water in the gravel channels in the lake basin. If the water level in the channels is low, water is discharged out of the "outlet" gravel channel on the southeast side of the lake. If water levels in the lake are high enough, as in the spring after a flooding event, water can be discharged out of the Big Sioux River inlet/outlet on the northeast end of the lake. Normal evapotranspiration which occurs on Pelican Lake can result in a loss of 33 inches (83 cm) of water per year (Kohler and others, 1959).

Additional surface water hydrologic monitoring results are included in the Tributary Hydrology section included later in this report.

APPENDIX D.

PLANTS ANIMALS
and
FISH
of the
Pelican Lake Area



SOUTH DAKOTA GAME, FISH AND PARKS
FIVE YEAR FISHERIES MANAGEMENT PLAN

Pelican Lake, Codington County
1989-1993

I. Inventory

Water No: 5-3 Yr. Last Survey: 1987 Mgt. Class: WWM Priority: 7.3
Size: 2795 acres Depth: Max-8.0, Ave-5.5 Littoral: 2795 acres Type: N
Shape: O Veg. Density: Submerge-6698 ac. Emerg-165 ac. Outlet Structure Type: CSW
Barriers: No Subimp: No Rearing Pond(s): No No. Access Areas: 3 Boat Ramps/Type: 3/CP Docks: 3 Toilets: 6

Species managed, reproduction and population potential, condition and trend:

Species	Repr Pot.	Pop. Pot.	Pop. Cond	Population Trends
Primary Game Fish				
Walleye	F	P	G	Average-slowly increasing since 1978
Northern Pike	F	F	P	Below average-declining since 1978
Yellow Perch	G	G	G	Above average-increasing since 1978
Secondary Game Fish				
Rock Bass	P	P	P	Below average-slightly increasing since 1978
White Bass	P	P	P	Below average-slightly increasing since 1978
Largemouth Bass	P	F	P	Below average-slightly increasing since 1978
Bluegill	P	F	P	Below average-slightly increasing since 1978
Black Crappie	F	F	P	Below average-slightly increasing since 1978
Black Bullhead	F	F	F	Below average-slightly increasing since 1978
Primary Forage				
Emerald Shiner	F	F	F	Average-fluctuating since 1978
Spottail Shiner	F	F	F	Average-fluctuating since 1978
Fathead Minnow	F	F	F	Below average-fluctuating since 1978
Johnny Darter	P	F	F	Average-fluctuating since 1978
Other Species				
White Sucker	F	F	G	Average-slightly declining since 1978
Carp	P	P	P	Below average-declining since 1978
Bigmouth Buffalo	P	P	P	Below average-declining since 1978

II. Problems

Biological (fish population, forage, growth reproduction, harvest, rank 1,2,3, in priority)
1. Low water levels - winterkills frequently
2. Poor recruitment for northern pike
3. Recruitment of yellow perch can be excessive
4. Apparent poor survival of northern pike stocks
5. Emigration of northern pike from Pelican Lake

Environmental (water quality, or quantity, enriched, vegetation, rank 1,2,3 in priority)
1. Submergent vegetation can become very abundant
2. Frequent summer and winterkills
3. Nutrient enrichment is a minor problem
4. Moderate algal blooms

Physical (depth, size, shape, structure, outlets, etc., rank 1,2,3 in priority)
1. Overall depth is poor
2. Lacks structure and habitat diversity (walleye and northern spawning sites)
3. Spillway has been repaired and is in excellent shape

Access and Others (areas, ramps, roads, signs, facilities, etc., rank in priority)
1. Access is good on three state areas (two being state parks)
2. Concrete plank ramps and docks are available at all areas
3. Parking areas are adequate

III. Management Needs and Actions

Analysis and Evaluation

Uses, Value, and Importance :
Pelican Lake has a priority rating of 7.3. It is an important fishery to Region IV. Pelican Lake is of major value to the community of Watertown (especially for the large yellow perch population), and has been used as a source of northern pike eggs and yellow perch broodstock. Pelican Lake can supply 35,000 user days of fishing.

Fisheries Assessment Schedule (surveys or studies needed):

Year	Type	Duration
1990	Lake Survey - General	1 week
1993	Lake Survey - General	1 week

Management Action Schedule (five year minimum)

Population control:

Removal

Year	Species	Type	Quantities
1989-1993	Rough fish	Contract	100#/acre/year

Stocking

Year	Species and Strain	Size	Number	Type
1989-1993	Northern Pike	4"	50,000	M

Access Development Schedule

Year	Type	Number	Location
1989-1992	Roads	2	Section 10
1989-1990	Docks and Ramps	5	Sections 9 and 10
1990	Parking	1	Section 10
1990	Trees	20	Section 9
1990	Fence	1	Section 9

Access Maintenance Schedule

Year	Type/frequency	Location
1989-1993	Roads and Trails/annual	Sections 1, 9 and 10
1989-1993	Docks and Ramps/annual	Sections 1, 9 and 10
1989-1993	Parking/annual	Section 1
1989-1993	Toilet/annual	Sections 9 and 10
1989-1993	Maintenance Visits/annual	Sections 1, 9, and 10

Public Information Programs

Year	Type	Number	Location
1989-1993	Article	1/year	Watertown Public Opinion
1989-1993	Radio	2/year	KWAT
1989-1993	Meetings	1/year	Watertown

FISH STOCKING

Fisheries management in Pelican Lake has included a rigorous stocking program for northern pike and white crappie before 1990. Recent fish stocking activities in Pelican Lake have intensified since the drop in yellow perch CPUE in 1990. Yellow perch populations in the lake have taken top priority and the stocking records reflect this change

Pelican Lake fish stocking records 1983-1994

SPECIES	SIZE	NUMBER	YEAR
NOP	FRY	150,000	1983
NOP	FGL	68,100	1983
WHC	ADT	200	1983
NOP	FGL	48,600	1984
BLC	ADT	250	1984
NOP	FGL	46,350	1985
NOP	FRY	221,000	1985
BLC	ADT	4,500	1985
WHC	ADT	8	1985
WHC	FGL	1,000	1985
NOP	FGL	58,000	1986
NOP	FGL	18,200	1987
NOP	FGL	17,800	1988
NOP	FGL	87,000	1989
YEP	ADT	34,400	1991
YEP	FGL	75,000	1991
WAE	SFG	280,000	1992
YEP	EGG	3,300,000	1992
YEP	FGL	31000	1993

ADT = ADULT EGG = EGG FRY = FRY
FGL = FINGERLING SFG = SMALL FINGERLING

NOP = NORTHERN PIKE WAE = WALLEYE
YEP = YELLOW PERCH BLC = BLACK CRAPPIE
WHC = WHITE CRAPPIE

COMMERCIAL FISHING

Commercial fishing for rough secondary species in Pelican Lake has been occurring for many years with catches being comparably large (see following tables). After the fall in yellow perch numbers in 1990 and the substantial increase in black bullhead numbers in frame net sampling a rigorous harvesting operation to control the black bullhead populations in Pelican Lake was begun.

Pounds of Fish Removed by Commercial Fishermen From Big Stone, Pelican, Traverse, Poinsett, and Kampeska, 1988-1992.

BIG STONE	YEAR	CARP	CARP SUCKER	F. WATER DRUM	BIGMOUTH BUFFALO
	1988	25000	0	0	0
	1989	267000	0	0	0
	1990	449000	0	29000	0
	1991	416000	0	27200	0
	1992	--NO DATA AVAILABLE			
	1993	477200	3600	42000	15300
	1994	--NO DATA AVAILABLE			
	TOTALS	**1157000**	**3600**	**56200**	**15300**

PELICAN	YEAR	CARP	BIGMOUTH BUFFALO	BLACK BULLHEAD
	1988	0	0	0
	1989	0	0	242500
	1990	0	0	262500
	1991	171000	31000	0
	1992	45500	7800	0
	1993	30000	1000	0
	1994	157000	2500	0
	TOTALS	**216500**	**38800**	**505000**

POINSETT YEAR	CARP	B. MOUTH BUFFALO	BLACK BULLHEAD	WHITE BASS	WHITE SUCKER
1988	416000	68200	100150	0	0
1989	925745	54425	0	18550	21130
1990	541700	143800	0	5150	0
1991	640500	23100	0	19968	5705
1992	246100	6400	0	10075	0
1993	586700	5500	0	5105	0
1994	226500	18600	0	3890	0
TOTALS	**2770045**	**295925**	**100150**	**53743**	**26835**

TRAVERSE YEAR	CARP	BIGMOUTH BUFFALO	F. WATER DRUM	WHITE BASS	CARP SUCKER
1988	289500	19700	49900	4000	2800
1989	329000	25900	103200	0	0
1990	107000	36000	42000	0	1000
1991	290000	17000	38000	0	0
1992	121500	5200	17400	0	0
1993	--NO DATA AVAILABLE				
1994	95800	5700	0	0	0
TOTAL	**1137000**	**103800**	**250500**	**4000**	**3800**

KAMPESKA YEAR	CARP	BIGMOUTH BUFFALO	WHITE BASS
1988	51900	34000	900
1989	1200	0	1900
1990	19500	0	4800
1991	9500	7350	1100
1992	7100	0	7500
1993	1200	0	0
1994	10000	4500	700
TOTALS	**89200**	**41350**	**16200**

BIOLOGICAL RESOURCES AND ECOLOGICAL RELATIONSHIPS

Plants

Pelican Lake is located in the Coteau des Prairies division of the Central Lowlands physiographic province. The flora of the region is characterized as Eastern Deciduous and Tall Grass Prairie. Although substantial amounts of grassland still occur west of the Missouri River, the Tall Grass Prairie in the eastern part of South Dakota has largely been plowed and its potholes drained so that very few remnants remain. The prairie remnants that remain are either heavily overgrazed or so disturbed that only indicator species can be found (Van Bruggen, 1976).

Trees, shrubs, and aquatic plants considered typical of the Eastern Deciduous Region are listed below. In addition to these typical vegetative types, several relatively rare plants are found in the Pelican Lake area. A listing of these rare plants is included on the following page.

Several State and Federal endangered or threatened species are also present in the Pelican Lake region. These species are at the end of the plant section.

Representative Listing of Trees, Shrubs, and Aquatic Plants Characteristic of the Eastern Deciduous Region.

Acer saccharum Sugar Maple	Prunus americana American plum	Amelanchler sanguinea Serviceberry
Quercus macrocarpa Bur Oak	Celtis occidentals Hackberry	Rhamnus lanceolata Buck thorn
Corylus americana American Hazelnut	Ribes cynosbatl Prickly Gooseberry	Euonymous atropurpurea Burning - bush
Tilia americana Basswood	Gymnocladus dioca Kentucky Coffee Tree	Ulmus thomasil Rock Elm
Juglans nigra Black Walnut	Viburnum lentago Sweet Viburnum	Ostrya virginiana Ironwood
Viburnum rafinesqulanum Downy Arrow-wood	Anemone quinquefolia Wood Anemone	Prenanthes alba White Rattlesnake Root
Arabis canadensis Rockcress	Solidago flexicaulis Goldenrod	Asarum canadense Wild Ginger
Trillium cernum Nodding Trillium	Caulophyllum thalictroldes Blue Conosh	Trillium nixale Snow Trillium
Cystopteris bulbifera Bulblet Bladder Fern	Uvularla grandiflora Small-Flowered Bellwort	Erythronium albidum Glacier Lily
Geranium maculatum Geranium	Hystrix patula Bottlebrush Grass	

AQUATIC PLANTS of the PELICAN LAKE REGION

Alisma plantago-aquatica
Water Plantain

Sagittaria cuneata
Arrowhead

Eleocharis macrostachya
Spike Rush

Typha angustifolia
Cattail

Lemna minor
Duckweed

Potamogeton pectinatus
Sago Pondweed

Cyperus ferruginescens
Galingale

Sparganium eurycarpum
Bur Reed

Juncus dudleyi
Rush

Utricularia vulgaris
Bladderwort

Cicuta maculata
Water Hemlock

Scirpus validus
Bullrush

Equisetum hyemale
Horsetail

Typha latifolia
Cattail

Potamogeton nodosus
Pondweed

Van Bruggen, 1976

LIST OF RARE PLANTS IN THE PELICAN LAKE REGION.

Acer saccharum
Sugar Maple

Hystrix patula
Bottlebrush Grass

Aralia racemosa
Spikenard

Leersia virginica
Virginia Cutgrass

Aster umbellatus
Flattop Aster

Potamogeton amplifolius
Largeleaf Pondweed

Carex lacustris
Lake Sedge

Sparganium chlorocarpum
Green-fruited Bur Reed

Corallorhiza trifida
Pale Coral-root

Dentaria laciniata
Toothwart

Uvularia grandiflora
Large-flowered Bellwort

Trillium cernuum
Nodding Trillium

Geranium maculatum
Wild Cranesbill

Anemone quinquefolia
Wood Anemone

Lactula floridana
Florida Lettuce

Aster borealis
Rush Aster

Populus balsamifera
Balsam Poplar

Carex capillaris
Hair Sedge

Salix humills
Prairie Willow

Caulophyllum thalictroides
Blue Cohosh

Spiranthes magnicamporum
Nodding Ladies Tresses

Trillium flexipes
Declining Trillium

Gentianopsis procera
Small Fringed Gentian

Acorus americanus
Sweetflag

Juncus articulatus
Jointed Rush

Asarum canadense
Wild Ginger

Najas marina
Water Nymph

Cacalla plantaginea
Indian Plantain

Prenanthes alba
White Rattlesnake Root

Carex pedunculata
Peduncled Sedge

Spiraea alba
Meadow Sweet

Cypripedium candidum
White Lady-slipper

Gentiana puberulenta
Downy Gentian

Zizania aquatica
Wild Rice

STATE AND FEDERAL ENDANGERED OR THREATENED SPECIES IN THE PELICAN LAKE REGION.

NAME	STATUS
Plantanthera leucophaea Prairie Fringed Orchid	Federal Candidate Species
Hesperia dacotae Dakota Skipper Butterfly	Federal Candidate Species
Falco peregrinus Peregrine Falcon	Federal, State Endangered
Grus americana Whooping Crane	Federal, State Endangered
Hallaeetus leucocephalus Bald Eagle	Federal, State Endangered
Umbra limi Central Mudminnow	State Endangered
Percopsis omiscomaycus Troutperch	State Threatened
Storeria dekayl Texas Brown Snake	State Threatened
Storeria occipitomaculata Redbelly Snake	State Threatened

Houtcooper, et. al., 1985

Animals

The animal species of the Pelican Lake region are quite diverse because of the intermixing of the Eastern Deciduous habitat with the Tall Grass Prairie habitat. Game animals and birds managed by the South Dakota Department of Game, Fish and Parks and their relative densities are listed below.

In addition to game species, the Pelican Lake region supports many non-game and/or rare species. These species, which are sensitive to habitat changes or other disturbances, are listed on the following page

Non-Game and Rare Species Potentially Occurring in the Pelican Lake Region on the following page, lists other species that could potentially occur in the Pelican Lake area, but have not been confirmed. In addition to the species listed previously, the habitat surrounding Pelican Lake supports a large variety of other animals, plants, and birds common to both the Eastern Deciduous and Tall Grass Prairie biomes.

RELATIVE DENSITIES OF GAME SPECIES IN THE PELICAN LAKE REGION

SPECIES	RELATIVE DENSITY
White-tail deer	medium-high
Mule deer	very low
Antelope	very low
Wild turkey	very low
Sharp-tailed grouse	very low
Ring-necked pheasant	medium
Gray partridge	medium-high
Ducks (native)	medium
Geese (native Canada)	medium
Mourning dove	low
Cottontail rabbit	medium
Tree squirrel	high
Mink	high
Beaver	high
Muskrat	low
Skunks	low
Weasels	medium
Badger	low
Coyote	medium-low
Foxes	medium
Raccoon	high
Jackrabbits	medium

South Dakota Department of Game, Fish and Parks

NON-GAME AND RARE SPECIES IN THE PELICAN LAKE REGION.

Accipiter cooperi
Cooper's Hawk

Culaea inconstans
Brook Stickleback

Hyla versicolor
Gray Treefrog

Opheodrys vernalis
Western Smooth Green Snake

Tamias striatus
Eastern Chipmunk

NON-GAME AND RARE SPECIES POTENTIALLY OCCURRING IN THE PELICAN LAKE REGION.

Amia calva
Bowfin

Podiceps grisegena
Horned Grebe

Charadrius melodus
Piping Plover

Scolopax minor
American Woodcock

Hiodon tergisus
Mooneye

Sorex palustris
Water Shrew

Microsorex hoyl
Pygmy Shrew

Zapus princeps
Western Jumping Mouse

Nycticorax violaceus
Yellow-Crowned Night Heron

Butorides striatus
Green-Backed Heron

Rana sylvatica
Wood Frog

Egretta caerula
Little Blue Heron

Sorex arcticus
Arctic Shrew

Lophodytes cucullatus
Hooded Merganser

Vireo flayltrons
Yellow-Throated Vireo

Necturus maculosus
Mudpuppy

Buteo platypterus
Broad-Winged Hawk

Podiceps grisegena
Red-Necked Grebe

Clethrionomys gapperi
Gapper's Red-Backed Vole

Sialla sialis
Eastern Bluebird

Larsus californicus
California Gull

Sterna hirundo
Common Tern

Moxostoma erythrurum
Golden Redhorse

Midwest Research Institute, 1974

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